READABILITY AND QUALITY OF WEB-BASED INFORMATION RELATED TO NOISE-INDUCED HEARING IMPAIRMENT

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Abstract

Aims: The purpose of this study was to assess the readability of online information pertaining to noise-induced hearing impairment (NIHI). This study aimed to answer several research questions: (1) What is the readability of online written information associated with searches related to NIHI? (2) Is the readability of online information significantly higher than the recommended 6^{th} grade levels proposed by many researchers (Cheng & Dunn, 2015; Eloy et al., 2012; McInnes & Haglund, 2011; Misra, Kasabwala, Agarwal, Eloy, & Liu, 2012; Narwani, Nalamada, Lee, Kothari, & Lakhani, 2015; C. R. Patel, Sanghvi, Cherla, Baredes, & Eloy, 2015; Walsh & Volsko, 2008)? (3) Are there significant differences in the readability of NIHI-related online written material from different organisation origins (OOs)? (4) Are there significant differences in the readability of NIHI-related online material from different country origins (COs)? (5) Does webpage origin significantly interact with the presence of a Health On the Net (HON) certificate?

Method: To answer the first four research questions, the researcher used five search terms derived from Google Trends that related to noise NIHI. These search terms were used to identify the first 10 relevant webpages associated with NIHI across 26 different English-language country coded top-level domains from Google. A total of 153 webpages were copied into Microsoft Word documents, which then underwent a readability analysis using Readability Studio (Oleander Software, 2012). To address the final research question, the researcher entered the root web address from each webpage into a HON search where the presence of a HON certification was determined.

Results: The readability of the online information was significantly higher than recommended levels and the presence of a HON certificate was low. Webpages of a commercial origin were found to have significantly better readability than webpages of a governmental origin, across two out of the three readability measures used. There was no significant effect of CO on readability scores. The presence of a HON certificate was not significantly related to OO as per a chi-squared analysis; however, there was a significant interaction between the presence of a HON certificate and CO.

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ANOVA –	Analysis of Variance
CIA –	Central Intelligence Agency
CO –	Country of Origin
ccTLD(s) –	country coded Top-Level Domain(s)
dB –	Decibel
dB –	Decibel A-Weighted
DV –	Dependent Variable
DRC –	Damage Risk Criteria
F-K –	Flesch Kincaid
FM –	Frequency Modulated
FOG –	Frequency of Gobbledygook
FRE –	Flesch Reading Ease
GDP –	Gross Domestic Product
HBM –	Health Belief Model
HCA –	Hearing Conservation Amendment
HCP –	Hearing Conservation Program
HI –	Hearing Impairment
HINTS –	Health Information National Trends Survey
HPD –	Hearing Protection Device
ICF –	International Classification of Functioning, Health and Disability
ISO –	International Organization for Standards
IT –	International Telecommunication Union
IV –	Independent Variable
MANOVA –	Multivariate Analysis of Variance
MDD –	Major Depressive Disease
NAAL –	National Assessment of Adult Literacy
NALS –	National Adult Literacy Survey
NHS –	National Heal Service
NIA –	National Institute of Aging
NIHI –	Noise Induced HI
NIHL –	Noise Induced Hearing Loss
NIOSH –	(American) National Institute of Occupational Health and Safety
NVS –	Newest Vital Sign
OC –	Origin by Country
OO –	Organisation of Origin
OSHA –	Occupational Safety and Health Administration
PTS –	Permanent Threshold Shift
RGL(s) –	Reading Grade Level(s)
REALM –	Rapid Estimate of Adult Literacy in Medicine
SMOG –	Simple Measure of Gobbledygook
s-TOFHLA –	shortened-Test of Functional Health Literacy in Adults
TOFHLA –	Test of Functional Health Literacy in Adults
TLD(s) –	Top-Level Domain(s)
TTS(s) –	Temporary Threshold Shift(s)
TWA –	Time Weighted Average
URL –	Uniform Resource Locator
US –	United States

USDHHS – US Department of Health and Human Services
VEP – Vocational Enablement Program
WHO – World Health Organization

1 Introduction

1.1 Overview

Noise-induced hearing impairment (NIHI) is one of the most common health issues associated with exposure to noise (Pawlaczyk-Luszczynska, Dudarewicz, Zaborowski, Zamojska, & Sliwinska-Kowalska, 2013; Pelegrin, Canuet, Rodríguez, & Morales, 2015) yet many researchers argue it is preventable (Brady & Hong, 2006; Davies, Marion, & Teschke, 2008; Griffin, Neitzel, Danniell, & Seixas, 2009; Nair, 2014; Nandi & Dhatrak, 2008; Nelson, Nelson, Concha-Barrientos, & Fingerhut, 2005; D. S. Patel et al., 2010; WHO, 1997; WHO, 2004; WHO, 2015b).

While legislation and preventative measures are well-established in much of the developed world, NIHI remains a common and on-going issue that has the ability to negatively impact on the quality of life for those who experience it (Arlinger, 2003; Canton & Williams, 2012; Noble, 2009). Research on the barriers to hearing protection device (HPD) use has established that comfort (Arezes & Miguel, 2002, 2006; Nandi & Dhatrak, 2008; D. S. Patel et al., 2010; Reddy, Welch, Thorne, & Ameratunga, 2012; Tak, Davis, & Calvert, 2009), communication difficulties (Morata et al., 2005; D. S. Patel et al., 2010), perceived benefits (Reddy et al., 2012), subjective norms and workplace safety climates (Bockstael, De Bruyne, Vinck, & Bottleooren, 2013; D. S. Patel et al., 2010), risk perception (Arezes & Miguel, 2006; Bockstael et al., 2013; Reddy et al., 2012), and low self-efficacy (Arezes & Miguel, 2006; Bockstael et al., 2013) all affect HPD use.

The Health Promotion Model highlights that improving self-efficacy via education will promote healthy behaviours like HPD use (Lusk, Ronis, Kerr, & Atwood, 1994), however issues including low health literacy among consumers and difficult to read health-related materials may hinder consumer access to information (Nutbeam, 2008). Many researchers highlight that the Internet is widely used for searching health information (Cheng & Dunn, 2015; Eloy et al., 2012; Laplante-Lévesque, Brännström, Andersson, & Lunner, 2012; Laurent & Vickers, 2009; McInnes & Haglund, 2011; Narwani et al., 2015; Walsh & Volsko, 2008; Ybarra & Eaton, 2005). It is therefore recommended that web-based health information is monitored to ensure it is presented in a readily accessible, readable format for consumers (Laplante-Lévesque et al., 2012). Recent research on the readability of web-based information surrounding common health issues (Atcherson et al., 2014; Cheng & Dunn, 2015; Laplante-Lévesque et al., 2012; McInnes & Haglund, 2011; Potter, 2015; Walsh & Volsko, 2008) has consistently demonstrated that the levels of health-related written material exceed the recommended 6th grade proposed by many researchers (Cheng & Dunn, 2015; Eloy et al., 2012; McInnes & Haglund, 2011; Misra et al., 2012; Narwani et al., 2015; C. R. Patel et al., 2015; Walsh & Volsko, 2008).

While research on the readability of health materials is increasing, web-based material related to NIHI is yet to be investigated. Hence, the present study sought to draw from the methodology presented in Laplante-Lévesque et al. (2012) who examined the readability of hearing-related online information, in an effort to establish the readability of web-based information related to NIHI.

1.2 Hearing Impairment

The human ear can be divided into four portions: the outer ear, middle ear, inner ear, and central auditory nervous system (Yost, 2007). The outer ear is made up of the pinna (external ear) made of cartilage and skin, ear canal and tympanic membrane (ear drum) (Yost, 2007). The pinna funnels sound down the ear canal toward the tympanic membrane causing it to vibrate (Yost, 2007). The tympanic membrane is attached to the ossicles (three ear bones) in the middle ear (Yost, 2007) and its vibration causes the ossicles to move in a mechanical motion (Bess & Humes, 2009; Yost, 2007). This motion results in pressure at the entrance to the inner ear strong enough to aid the transmission of sound from the air-filled middle ear into the fluid-filled cochlea of the inner ear (Yost, 2007). These sounds are then processed by a sense organ called the organ of Corti (Bess & Humes, 2009).

The organ of Corti is lined with thousands of sensory receptor cells called outer and inner hair cells and lies on top of the basilar membrane (Bess & Humes, 2009; Yost, 2007). The cilia (hair-like tips) of outer hair cells are embedded in a membrane called the tectorial membrane (Bess & Humes, 2009; Yost, 2007). With the upward movement of the basilar membrane in response to sound, the cilia on the outer hair cells undergo displacement in a shearing motion (Bess & Humes, 2009). This shear motion initiates electrical and chemical processes (Bess & Humes, 2009; Yost, 2007). Outer hair cells serve to amplify incoming sounds, while inner hair cells convert the sound waves into electrical signals that are sent to the brain via the auditory nerve (Yost, 2007).

Hearing impairment (HI) is the result of loss or abnormalities of the structure and/or function of the hearing mechanism (Bess & Humes, 2009). A HI can be unilateral (affecting one ear) or bilateral (affecting both ears) (Bradden, 2000). HI is defined by type, configuration, and severity. The type of HI generally indicates the site of lesion. Configuration represents the shape of the HI when behavioural hearing thresholds are presented graphically on an audiogram, with the hearing level (in decibels [dB]) on the y-axis and octave frequencies (in hertz [Hz]) up to 8000 Hz on the x-axis. Configuration may be described as flat, falling, rising (gradually, sharply, or precipitously), peaked, troughed, or notched (Carhart, 1945; Lloyd & Kaplan, 1978). According to Bess and Humes (2009) a threshold of 0 dB HL represents a normal level of hearing sensitivity for a young adult, and as hearing sensitivity decreases, the threshold (in dB HL) increases on an audiogram. However, according to three well-known hearing classifications, the first degree of HI (slight or mild) ranges from 16-26 dB (Goodman, 1965; Jerger & Jerger, 1980; Northern & Downs, 2002), therefore deeming a normal hearing threshold to include levels from 15-25 dB HL. HI can be classified as mild (26-40 dB HL), moderate (41-55 dB HL), moderately-severe (56-70 dB HL), severe (71-90 dB HL), or profound (>91 dB HL) (Goodman, 1965). However, there are varying classifications of HI (Jerger & Jerger, 1980; Northern & Downs, 2002). For example, Jerger and Jerger (1980) who classify a mild HI as 21-40 dB HL, do not include a moderately-severe classification, and consider profound HI as greater than 80 dB HL. While Northern and Downs (2002) include a slight HI (16-25 dB HL) as an additional category, disregard a moderately-severe classification, and classify a profound degree of HI as greater than 70 dB HL.

1.2.1 Conductive hearing impairment.

Conductive HI describes a problem in the structure or mechanics of the outer or middle ear (Bess & Humes, 2009). Conductive HI may can be caused by a number of factors including: blockages or occlusion of the external or middle ear, such as cerumen (ear wax) and/or foreign bodies, which can prevent the transmission of sound (Bess & Humes, 2009; Yost, 2007). An increase in the stiffness of the tympanic membrane or middle ear system due to: perforation or scarring of the tympanic membrane, ossicular chain disruption, and/or otosclerosis (a condition involving an increase in bone, which immobilises the stapes) also hinders sound transmission (Bess & Humes, 2009; Yost, 2007). An increase in the mass of the middle ear such as:

middle ear effusion (fluid), or a cholesteotoma (benign tumour) can also result in conductive HI (Bess & Humes, 2009; Yost, 2007). Inherited causes of conductive HI can give rise to severe deformities of the pinna (the external part of the ear) such as microtia (underdeveloped ear) and atresia (absence of ear canals) (Bess & Humes, 2009). Conductive HI is usually treatable by medical or surgical means (Bess & Humes, 2009).

1.2.2 Sensorineural hearing impairment.

A HI that is sensorineural in nature is due to impairment in the inner ear (sensory) or auditory nerve (neural) (Bess & Humes, 2009). According to Nair (2014), the most common cause of sensory HI in adults is presbycusis, or age-related impairment. Sensorineural HI can also occur as a result of exposure to noise, resulting in NIHI (Yost, 2007). Further, sensorineural HI can also arise from exposure to ototoxic (toxic to the ear) drugs or substances (Thorne, 2006; Yost, 2007). Examples of such ototoxic drugs are the cytotoxic compounds used as anti-cancer treatments (Thorne, 2006). Other potential ototoxins include solvents, fuels, metals, carbon monoxide, fumigants, herbicides and fertilisers (Thorne, 2006). Sensorineural HIs are typically permanent or irreversible (Bess & Humes, 2009). Common forms of rehabilitation include the use of hearing aids, personal listening devices such as frequency-modulated (FM) systems, and cochlear implantation (Bess & Humes, 2009; Kricos, 2006; WHO, 2015a). HIs may also be mixed. A mixed HI involves both sensorineural and conductive components, where the sensorineural component is better than the conductive component (Bess & Humes, 2009).

1.2.3 Prevalence.

The World Health Organization (WHO) estimates that approximately 642 million people globally are affected by a HI greater than 25 dB HL (World Health Organization [WHO], 2006). HI is regarded as one of the most common disabilities world wide, where one in four adults are said to experience some form of HI (WHO, 2004). This is a number that continues to rise as the world's population continues to age. The United Nations estimates that between 2015 and 2030, the population of people aged 60 years or over will grow by 56%, from 901 million to 1.4 billion, and then more than double by 2050, reaching 2.1 billion (United Nations, 2015).

1.2.4 Impact of hearing impairment.

HI can affect well-being, producing feelings of: frustration, sadness, isolation, anxiety, embarrassment, loss of confidence, and cause dependence on others (Goldman & Holme, 2010; Noble, 2009; D. S. Patel et al., 2010; WHO, 2004). Untreated HI is linked to fatigue associated with extra effort by both the speaker and listener, and concentration required by the individual with HI involved in conversation (Arlinger, 2003; Noble, 2009). HI is argued as the most common cause of tinnitus (Goldman & Holme, 2010; Mazurek, Olze, Haupt, & Szczepek, 2010), which, according to a retrospective study on 531 patients by Mazurek et al. (2010), results in increases in tinnitus loudness with increasing HI severity. Untreated HI may also affect the ability to maintain relationships due to its negative impact on communication (Verbeek, Kateman, Morata, Dreschler, & Mischke, 2014) and has been found to significantly impact on an individual's quality of life (Arlinger, 2003; Canton & Williams, 2012; Noble, 2009).

Several studies have investigated the effect HI has on working individuals (Backenroth-Ohsako, Wennberg, & Klinteberg, 2003; Jennings & Shaw, 2008;

Kramer, 2008; Kramer, Kapteyn, & Houtgast, 2006). Backenroth-Ohsako et al. (2003) found that participants with HI had higher levels of anxiety at work in comparison to a control group of participants with normal hearing. The authors suggest that increased anxiety levels may be the result of the participants' use of coping strategies, such as taking control of work situations, in an effort to overcome the burden of their HI (Backenroth-Ohsako et al., 2003).

Kramer et al. (2006) conducted a study that compared 151 employees with HI to 60 employees with normal hearing identified several significant differences between groups. Self-perceived environmental noise and listening effort were found to be greater in employees with HI (Kramer, 2008). Furthermore, employees with HI felt as though they had less control of the work environment, and had a higher number of sick days associated with stress (Kramer et al., 2006).

Jennings and Shaw (2008) conducted a qualitative study on three working individuals with HI to investigate the impact of HI on the workplace. While assistive technology and audiological rehabilitation helped to address some of the issues associated with having a HI and working, HI resulted in stress associated with impaired communication, impacted on the ability to participate and socialise in the work environment, and influenced the ability to maintain a job position (Jennings & Shaw, 2008). The authors concluded that there was a lack of awareness surrounding HI in the workplace and an urgent need for multi-disciplinary support services for working individuals with HI (Jennings & Shaw, 2008).

While Jennings and Shaw (2008) found that support services were lacking in Canada, a study by Kramer (2008) investigated the effectiveness of support services available to working individuals with HI in the Netherlands. Their study described the findings from 86 individuals who participated in what was then a newly developed vocational enablement program (VEP) involving the contributions from a multi-disciplinary team of several associated professions. The program featured various recommendations from the team for the participants to undertake. Among the most common recommendations were: hearing aid fittings and adjustments (recommended to 54% of participants), communication training in the form of lip-reading (31%), environmental modifications such as: the rearrangement of furniture, provision of light, and introduction of materials to improve room acoustics (30%), psychosocial counselling (21%), and using assistive listening devices (20%) (Kramer, 2008). While their study was limited by the fact it was based solely on empirical findings, it had some valuable insights. The majority of participants who completed the VEP stated that it had facilitated their participation in work, while 20% of participants experienced employers who were uncooperative with the recommendations (Kramer, 2008). These findings support those in Jennings and Shaw (2008), which surround the lack of awareness about HI in the workplace and need for further implementation of VEPs in other regions.

1.3 Noise-Induced Hearing Impairment

The (American) National Institute of Occupational Safety and Health defines noise as an "undesired sound" and "any unwarranted disturbance within a useful frequency band" (National Institute of Occupational Safety and Health (NIOSH), 1998, p. xiv). Noise can be defined in terms of its intensity and frequency (Nair, 2014). Prolonged exposure to high levels of noise can result in HI, which is the most common disorder associated with exposure to noise (Fligor, Chasin, & Neitzel, 2015; Pawlaczyk-Luszczynska et al., 2013; Pelegrin et al., 2015) and the second most common cause of sensorineural HI, after presbycusis (Nandi & Dhatrak, 2008; Sliwinska-Kowalska & Pawelczyk, 2013). NIHI is considered permanent and irreversible, yet commonly argued as preventable (Brady & Hong, 2006; Davies et al., 2008; Griffin et al., 2009; Nair, 2014; Nandi & Dhatrak, 2008; Nelson et al., 2005; D. S. Patel et al., 2010; WHO, 1997; WHO, 2004; WHO, 2015b). According to Nair (2014), the first scientific link between HI and occupational noise exposure was established in 1886 by a British physician, Thomas Barr, who noted deafness among boilermakers in Glasgow.

1.3.1 Causes of noise-induced hearing impairment.

According to Nair (2014), NIHI can result from three subcategories, namely, socioacousis, acoustic trauma, and occupational NIHI. However, the subcategories are not always mutually exclusive, where acoustic trauma could result from a work-related or recreational activity. Socioacousis presents as the result of recreational or non-occupational noise exposure (Nair, 2014). An example of socioacousis might include an individual who has developed NIHI from attending regular music concerts, without the use of HPDs. Acoustic trauma results from short-term, high-intensity exposure to noise, such as an explosion (WHO,Nair, 2014; 2015b). An example of acoustic trauma might include a gun being shot without warning within close range.

NIHI is said to develop in two stages (Nair, 2014). The first is a temporary impairment of hearing, termed a temporary threshold shift (TTS) (Arezes & Miguel, 2002, 2005, 2013; Fligor et al., 2015; Hong, Kerr, Poling, & Dhar, 2013; Nair, 2014; D. S. Patel et al., 2010; Rajguru, 2012; Ranga, Yadav, Yadav, Yadav, & Ranga, 2014; Steyger, 2009; Thorne, 2006; Thorne et al., 2008; Yost, 2007). TTS is caused by hair cell fatigue (Rajguru, 2012), where an individual may experience a HI characterised by auditory dullness (Ranga et al., 2014; Thorne, 2006; Thorne et al., 2008). TTS may also be accompanied by the sensation of a sound such as ringing or buzzing in the absence of an external sound source, termed tinnitus (Sliwinska-Kowalska & Davis, 2012). The HI associated with a TTS typically recovers within a day (Hong et al., 2013; Yost, 2007). If a TTS occurs too often, it can become a permanent threshold shift (PTS), where the impairment in hearing is ultimately irreversible (Fligor et al., 2015; Hong et al., 2013; Nair, 2014; Nakai, 2003; D. S. Patel et al., 2010; Rajguru, 2012; Ranga et al., 2014; Steyger, 2009; Thorne, 2006; Thorne et al., 2008; Yost, 2007). This is thought to be due to a functional disruption of the Organ of Corti due to loss of hair cells and supporting fibres (Nair, 2014; Nakai, 2003; Rajguru, 2012).

Noise damage is usually slow and progressive (Hong et al., 2013; McReynolds, 2005; Nair, 2014; Sliwinska-Kowalska & Davis, 2012). However, higher sound levels and longer exposure times also increase the risk for NIHI (Nandi & Dhatrak, 2008). Damage to the hair cells initially occurs among those encoding high frequency sounds (Nair, 2014; Nandi & Dhatrak, 2008; D. S. Patel et al., 2010; WHO, 1997), with a typical notch at 3000 – 6000 Hz, and the largest effect is typically at 4000 Hz (Nair, 2014; D. S. Patel et al., 2010; Pawlaczyk-Łuszczyńska, Dudarewicz, Zamojska, & Śliwinska-Kowalska, 2012; Pawlaczyk‐Luszczynska et al., 2013; Ranga et al., 2014; WHO, 2004). This is because hair cells in the basal coil of the cochlea are responsible for transducing the higher frequencies and therefore more sensitive to noise damage (WHO, 1997)

NIHI is usually bilateral (Nair, 2014; Nandi & Dhatrak, 2008; Thorne, 2006), rarely profound, and typically does not progress once exposure has stopped (Nair, 2014). However, a longitudinal study by Gates, Schmid, Kujawa, Nam, and D'Agostino (2000) found differences in audiograms over a 15-year period among participants who had a history of occupational noise exposure and those who did not. They argue that the effects of NIHI continue long after noise exposure ceases (Gates et al., 2000).

NIHI can be influenced by environmental factors such as exposure to recreational noise and ototoxic chemicals, and individual factors including smoking, hypertension, high cholesterol, age (Nandi & Dhatrak, 2008; Pawlaczyk-Łuszczyńska et al., 2012; Yost, 2007). HIs from different causes can be additive (WHO, 1997) and NIHI may add to presbycusis to produce a HI sooner and worse than presbycusis alone (WHO, 1997; WHO, 2015b). NIHI has a higher prevalence and is said to have a much heavier burden among developing nations where access to health services are limited and legislation may be inadequately enforced (Fuente & Hickson, 2011; Rosso, Aglus, & Calleja, 2011; Thorne, 2006).

1.3.1.1 Occupational noise-induced hearing impairment.

NIHI is considered to be one of the most common occupational and environmental health hazards (Pawlaczyk‑Luszczynska et al., 2013; Pelegrin et al., 2015). Occupational NIHI is the result of repeated or sustained exposure to high intensity noise in a work environment and is said to be a major cause of HI among adults globally (Nair, 2014; D. S. Patel et al., 2010; Pawlaczyk-Łuszczyńska et al., 2012; Pawlaczyk-Luszczynska et al., 2013; Ranga et al., 2014; Thorne, 2006; Thorne et al., 2008; Thurston, 2013), contributing toward an estimated one-sixth of HI worldwide (Nandi & Dhatrak, 2008; Nelson et al., 2005; Robertson, Kerr, Garcia, & Halterman, 2007; Verbeek et al., 2014).

Occupational exposure to ototoxic chemicals including solvents is also said to damage the hair cells of the inner ear (Campo & Maguin, 2007; Hong et al., 2013; Steyger, 2009). Steyger (2009) argued that solvents, such as jet fuel paint fumes and spray adhesives, together with high-level noise exposure can potentiate the risk of HI, although the mechanisms for this are not fully understood. However, a study by

Dement, Ringen, Welch, Bingham, and Quinn (2005) involving 3510 participants, found no such effect of solvents, although they failed to identify the type of solvents to which workers had been exposed. Campo and Maguin (2007) suggested some solvents allow higher acoustic energy penetration into the cochlea. They also recommended that hearing protection should be implemented at lower levels than the standards suggested, when workers were exposed to noise and solvents simultaneously.

1.3.1.2 Prevalence of occupational noise-induced hearing impairment.

Occupational NIHI can affect all age groups (Nair, 2014) however, it is usually the result of long-term exposure to noise and thus, more common among older individuals who have been exposed to noise throughout their working life. Occupational NIHI is alleged to be more prevalent among males than females (Eng et al., 2010; Exeter, Wu, Lee, & Searchfield, 2015; Nelson et al., 2005; Noble, 2009; Reddy et al., 2012). Bradden (2000) stated that while there is no gender gap among individuals under 17 years of age, twice as many males experience HI over the age of 65 years. This gender gap has been evident worldwide and is likely due to the higher numbers of male workers in jobs where noise exposure is more widespread (Nelson et al., 2005)

Occupational HI is said to be prevalent in several sectors including agriculture, forestry and fishing, construction, manufacturing, mining, military, and transportation (Edelson et al., 2009; Griffin et al., 2009; Hong et al., 2013; National Institute of Occupational Safety and Health, 1998; Nelson et al., 2005; D. S. Patel et al., 2010; Tak et al., 2009; Thorne et al., 2008; WHO, 2004).

1.3.1.3 Impact of noise-induced hearing impairment.

NIHI may result in communication problems, particularly when understanding speech in the presence of background noise or reverberation (Arlinger, 2003; Morata et al., 2005; WHO, 2004), and can impact a person's ability to discriminate high-frequency sounds, or to identify, and localise sounds quickly and reliably (Arlinger, 2003; WHO, 2004). Exposure to noise may also be related to elevated blood pressure (van Kempen et al., 2002), and potentially associated with sleeping difficulties, annoyance, stress, and tinnitus (Nandi & Dhatrak, 2008; Nelson et al., 2005).

NIHI is considered a major economic burden (Pawlaczyk-Luszczynska et al., 2013), as it is the biggest compensable occupational hazard – estimated at 0.2 – 2% of the gross domestic product among developed nations (Nandi & Dhatrak, 2008; WHO, 1997). The negative effects of the economic burden are experienced more widely in developing nations and low and middle-income regions where access to rehabilitation is limited due to the cost involved (Nandi & Dhatrak, 2008; Stevens et al., 2013; WHO, 2004). In 2004, NIHI was ranked fifteenth among the leading causes of burden of disease (WHO, 2004). This ranking is projected to increase three or four places by 2030 due to the world's ageing population and an improvement in healthcare for other disease burdens (WHO, 2004).

1.3.2 Treatment.

There is typically no medical or surgical treatment for the sensorineural HI, and therefore, no curative treatment for NIHI (Nair, 2014; D. S. Patel et al., 2010; WHO, 2015b). However, further progression of NIHI can be prevented by limiting exposure to noise and using HPDs (WHO, 2015a). Recent research on pharmacological treatments and rescue agents for NIHI focused on understanding the biochemical events that cause damage to the Organ of Corti; however, none were able to manage NIHI as well as avoiding noise exposure (Rajguru, 2012).

For individuals with significant sensorineural HI, the usual course of treatment involves amplification from one or two hearing aids (Bess & Humes, 2009). While hearing aids have been found to significantly improve quality of life (Stark & Hickson, 2004), they cannot restore natural hearing or address the all of the issues associated with HI outlined in section 1.2.4, such as the management of HI in a work environment. Furthermore, seeking treatment for a significant HI takes an average of 10 years, where the average age at which someone obtains their first hearing aid is 74 years (A. Davis, Smith, Ferguson, Stephens, & Gianopoulos, 2007). Finally, as outlined in the previous section, the cost surrounding compensation and treatment for NIHI is a large economic burden (Pawlaczyk-Luszczynska et al., 2013). Therefore, efforts to remediate NIHI should focus on the prevention of NIHI through participation in hearing conservation programs (HCPs).

1.4 Hearing Conservation

1.4.1 History.

The development of HCPs commenced after the Second World War. The first HCP was established by the US Air Force in 1956 and named regulation 160-3 (Fligor et al., 2015; Suter, 2005). Regulation 160-3 required exposure limits, monitoring audiometry and the use of HPDs. In 1969, noise standards were introduced under the Walsh-Healy Public Contracts Act. The standards involved a HCP that applied exclusively to government employees. However, there were issues with the Walsh-Healey act and its wording that prevented the Department of Labor's ability to enforce its standards, such as audiometric testing. According to a previous report (Suter, 2005), companies refused to comply stating that it was not specified in the regulation.

In 1970, a new legislation, called the Occupational Health and Safety Act 1970 was passed (Suter, 2005). This act designated funding and research responsibilities to what was then, a newly-developed organisation called the National Institute for Occupational Safety and Health (NIOSH); located within the Department of Health, Education, and Welfare (Suter, 2005). It also designated the enforcement of occupational health and safety standards to a new section of the US Labor Department called the Occupational Safety and Health Administration (OSHA). Thus in 1971, the Walsh-Healey noise standard became an OSHA standard, which applied to most employers engaged working in noisy industry (Suter, 2005).

Following recommendations to revise the standards based on research by NIOSH in 1972, OSHA produced the revised Hearing Conservation Amendment (HCA) in 1981 (OSHA, 1981). However, following two years of political battles over its cost to American businesses, the standard was not published until 1983 (Suter, 2005). This standard, often called the OSHA Noise Standard is still in effect today and is the basis for many HCPs globally.

1.4.2 Legislation.

1.4.2.1 Damage risk criteria.

According to Suter (2005), setting standards for protection against hazardous noise must first include an analysis of the damage risk criteria (DRC). This means that the regulators must examine the available research to determine the levels, durations, and types of noise that produce various amounts of hearing loss in various segments of the exposed population (Suter, 2005). Issues that should be examined initially, include the amount of hearing to be preserved and the determination of an unacceptable degree of risk (Suter, 2005).

Research from the ISO, Environmental Protection Agency and NIOSH, estimated the percentage of the population at risk as a function of an 8-hour daily average noise exposure experienced over a 40 year working life. The data showed that the risk for a NIHI across the permissible exposure limits is 21-29% at 90 dBA, 10 to 15% at 85 dBA, and 0-5% at 80 dBA, where NIHI is determined by a loss greater than 25 dB HL at 500, 1000, and 2000 Hz. These frequency values have been altered in OSHA's current definition for HI, which includes 3000 Hz and excludes 500 Hz. Therefore, the levels of risk are likely to be higher (Suter, 2005).

The permissible limit used in the OSHA Noise Standard is 90 dBA over an 8-hour period (Suter, 2005). If an individual's noise exposure exceeds that 90dBA over 8-hours, the provisions of a HCP must take place. This is also termed the action level: where hearing conservation actions must commence. From the information above, the risk at 90 dBA ranges from 21-29% among employees. It is important to note that DRC cannot possibly protect the hearing of every employee, as there are individual factors to account for, such as individual susceptibility to HI and HPD non-use. As Suter (2005) highlighted, the development of DRC involves determining unacceptable risk levels. While this insinuates that OSHA deem 21-29% an acceptable level of the risk, OSHA implements aspects of HCPs to employees exposed to levels of 85 dBA. These elements include noise monitoring and the provision of HPDs, and help to minimise risk for employees who are not generally covered by the standard, and whose employers cannot justify the cost of administering engineering controls for noise exposure below 90 dBA.

According to Lipscomb (2005a) two DRC are in frequent use. The first is the OSHA used in the US. The second is the International Organization for Standards (ISO) document 1999-1975, used primarily in European countries (Lipscomb, 2005a). Neither of the DRC has a standard for maximum levels of exposure for short-term or single-event accidental conditions, or within the nonoccupational setting (Lipscomb, 2005a). Furthermore, noise exposure standards for both OSHA and ISO 1999-1975 relate to daily exposures to noise over many years throughout a working life (Lipscomb, 2005a). This highlights the fact that DRC do not account for non-occupational noise exposure (Lipscomb, 2005a). For employees exposed to non-occupational noise, the risk estimates for the permissible exposure levels (detailed above) would be even greater than stated. This reinforces the idea that, DRC cannot ensure the protection of all employees and highlights that “hearing conservation is a 24 hour concern” (Lipscomb, 2005a, p. 37).

1.4.2.2 Qualify, abate, protect.

According to Lipscomb (2005c) three fundamental principles provide the basis for all HCPs, namely: “qualify, abate, protect” (Lipscomb, 2005c, p. 3). Qualification involves the sound measurement and exposure analysis of noise in a workplace to determine whether it in excess of that stated in the OSHA standard (Lipscomb, 2005c). According to a summarised table in Lipscomb (2005c), for a sound level of 90 dBA, the permissible daily exposure would be 8 hours according to the OSHA noise standards. With every 5 dB increase in the sound level, the permissible daily exposure would halve (95 dBA = 4 hours permissible daily exposure). This process is termed time/intensity trading, where the trade rate is 5dB (Lipscomb, 2005c). While acoustical principles dictate that the doubling of energy is expressed as 3dB, less stringent criteria were adopted after consideration about the variability of noise exposure in a workplace (Lipscomb, 2005c). When the qualification process deems daily exposure in a certain area is within the permissible limits, no further steps in the HCP need to be taken. However, when daily exposure exceeds the permissible limits, abatement should be considered.

Abatement involves the reduction of noise at the source and is a compulsory part of hearing conservation when steady-state noise exceeds 100 dBA (Lipscomb, 2005c). Abatement can be achieved by two means. The first involves the use of engineering controls in an effort to reduce noise exposure through the modification or redesigning of equipment (Lipscomb, 2005c). The second involves the use of administrative controls, whereby workers are rotated between louder and quieter work areas to ensure their daily exposure is below the permissible limits designated by the OSHA standard (Lipscomb, 2005c). To validate administrative controls, qualification would need to be implemented again to show that repeatable measures are within the OSHA guidelines. Thereafter, qualification should be implemented periodically to ensure the sound exposure conditions remain within the OSHA guidelines. Should qualification indicate that sound exposure conditions exceed the permissible limits, the third step in the hearing conservation program (protect) would need to be applied (Lipscomb, 2005c).

Protection involves the use of hearing protection and monitoring audiometry to preserve the hearing, and assess whether the hearing mechanism is being affected by noise exposure (Lipscomb, 2005c). According to the HCA, employees whose time-weighted average (TWA) is equal to or exceeds 85 dBA should undergo annual training and education on HPD fit, care and use, yearly audiograms by a trained professional, and be provided with a range of appropriate HPDs for use (Suter, 2005). With regards to HPDs, the level of protection is ultimately determined by how the individual wears and uses the device (Berger, 2005). HPD use is mandatory for employees exposed to a TWA of 90 dBA and over, where employees should be offered a range of HPD styles that are suitable to the environment (Suter, 2005). Given that the protection element of HCPs is the most relevant aspect to the field of audiology, it is discussed in further detail.

1.4.2.3 National Institute for Safety and Health research.

Following the designation of funding by OSHA, NIOSH undertook large-scale research on NIHI. NIOSH published a criteria document in 1972 that provided recommendations on amending the OSHA Noise Standard including lowering the action level from 90 dBA to 85 dBA (Suter, 2005). The research proposed requirements for monitoring audiometry, warning signs, HPD provision, employee notification, and recordkeeping (Suter, 2005). Unfortunately, the 90 dBA action level remained due the cost of engineering and administrative controls that would have to be forfeited by employees, which was said to be politically and economically infeasible (Suter, 2005). However, OSHA did revise its legislation to include elements of HCPs for employees exposed to levels of 85 dBA, such as monitoring audiometry and the provision of HPDs. Although its proposals were altered, the 1972 research by NIOSH formed the foundations for the 1981 HCA.

A further-updated recommendation by NIOSH (NIOSH 1998) also recommended an 85 dBA action level as well as lowering the time/intensity trade level from 5 to 3 dB. Although OSHA has not updated its noise standards, possibly for the same reasons stated in 1983, organisations including the National Aeronautics and Space Administration, the US Department of Defence, and the American Academy of Audiology have revised their HCPs to incorporate the recommendations (Stevenson, 2017).

1.4.3 Hearing Protective Devices.

Common types of HPDs include earmuffs and earplugs (Thorne, 2006). Earmuffs consist of two, rigid, moulded-plastic earcups held in place by a headband or hardhat (Berger, 2005). Earmuffs fit over and around the ears (circumaural) and form a seal against the head using foam or fluid-filled cushions (Berger, 2005; Thorne, 2006). In comparison, earplugs are small cylindrical pieces of foam, rubber, or silicone that are inserted into the ear canals to form a seal (Berger, 2005; Thorne, 2006). Formable earplugs are made of slow-recovery foam that expands after it is inserted into the ear canal (Berger, 2005). Formable plugs are advantageous as they fit more ear canals than the more traditional premoulded earplugs developed during World War II (Berger, 2005). Earplugs may also be customised to an individual's ear. Custom earplugs are manufactured from material such as silicone, which is durable in comparison to foam-based earplugs, but also subject to shrinkage, hardening, and cracking over time (Berger, 2005). They are larger than traditional earplugs and fill part of the concha bowl (Berger, 2005). The attenuation levels of customised earplugs are subject to the initial impression of the individual's ear, as well as correct insertion (Berger, 2005).

1.4.3.1 Effectiveness.

HPDs do not prevent sound from reaching the ear; they merely create a semi-barrier or form of conductive HI that attenuates the level of incoming noise (Berger, 2005). The level of attenuation provided by HPDs can be limited by several factors (Berger, 2005). Air leaks occur when HPDs fail to make an air tight seal in the canal (for earplugs) or around the pinna (for earmuffs) (Berger, 2005). According to (Nixon, 1979), air leaks can reduce sound attenuation by 5 to 15 dB over a broad range of frequencies. HPD vibration in response to sound waves is also possible and can limit attenuation at 125 Hz from 25 to 40 dB depending on the type of HPD used (Berger, 2005). Material transmission of sound waves through HPDs can also occur, and has a larger effect for earmuffs, where attenuation is limited for frequencies above 1000 Hz (Berger, 2005).

1.4.4 Barriers to protection.

While HCPs should include a holistic approach involving qualification, abatement, and protection, the focus of many studies is protection and why workers exposed to hazardous noise fail to comply with safety legislation. Arezes and Miguel (2005) argue that simply making HPDs available to workers does not necessarily mean the workers will be better protected, as protection is dependent on the fit and usage of the device, as well as a worker's willingness to use the device. Many studies have investigated factors that affect the use of HPDs among workers (Arezes & Miguel, 2006, 2013; Bockstael et al., 2013; Brady & Hong, 2006; R. R. Davis & Shaw, 2011; Griffin et al., 2009; Neitzel & Seixas, 2005; D. S. Patel et al., 2010; S. Purdy & W. Williams, 2002; S. C. Purdy & W. Williams, 2002; Reddy, Welch, Ameratunga, & Thorne, 2014; Reddy et al., 2012; Robertson et al., 2007; W. Williams & Purdy, 2005). D. S. Patel et al. (2010) highlighted that previous literature has failed to properly define the concept of a barrier with regards to HPD use. Based on their qualitative study involving 31 miners, they suggested that two major barriers to HPD use exist, namely environmental and individual barriers (D. S. Patel et al., 2010). They defined environmental barriers as "…external realities that act as systematic constraints against behavioural change" and individual barriers as "…internally perceived cues that prevent engagement of healthy actions" (D. S. Patel et al., 2010, p. 160).

1.4.4.1 Environmental barriers.

Comfort was found to be a major environmental barrier for HPD use among workers exposed to high noise levels (Arezes & Miguel, 2002, 2006; R. R. Davis & Shaw, 2011; Nandi & Dhatrak, 2008; D. S. Patel et al., 2010; Reddy et al., 2012; Tak et al., 2009). R. R. Davis and Shaw (2011) measured the comfort of HPDs on 20 participants in a controlled setting and after 25 minutes of activity, humidity and temperature (measured at 10-second intervals) were found to significantly increase, and subjective comfort rating declined significantly.

D. S. Patel et al. (2010) identified several environmental barriers in their study. Workers were said to experience economic barriers associated with the fear of being demoted if they were to complain about the lack of hearing protection, and economic and medical barriers associated with time taken off work to treat ear infections caused by HPDs (D. S. Patel et al., 2010). Some workers were found to be unaware of the legislation associated with HPD use, and thus unmotivated to use HPDs on the premise that using them was not mandatory (D. S. Patel et al., 2010). These findings highlight that a lack of employee education surrounding legislation, and a lack of employer responsibility plays a major role in the use of HPDs among employees.

1.4.4.2 Individual barriers.

Communication difficulties present an individual barrier for the use of HPDs (Morata et al., 2005; D. S. Patel et al., 2010). Morata et al. (2005) interviewed 31 individuals with self-reported noise exposure and HI in an effort to evaluate their perspectives on the impact of HI on job safety and performance, and HPD use. Issues related to the use of HPDs included impaired communication and reduced ability to monitor the work environment (Morata et al., 2005). Although they reduced noise exposure, HPDs made communication more difficult and impaired an individual's ability to detect environmental sounds and warning signals (Morata et al., 2005), causing workers to develop feelings of fear, isolation, and frustration (D. S. Patel et al., 2010).

A further individual barrier is the perceived lack of benefit an individual has about HPDs, such as the idea that HPDs are ineffective or of a poor quality and therefore unnecessary for use (Reddy et al., 2012). The workplace safety climate and the subjective norms experienced by employees are also said to affect HPD use (Bockstael et al., 2013; D. S. Patel et al., 2010). A safety climate is a notion relating to the workplace and how individuals within it feel and use personal protective equipment such as HPDs (Bockstael et al., 2013). A subjective norm in this case, is how an individual perceives others in the workplace, and can influence the use of HPDs where employees modify their own behaviours to more closely reflect that of their co-workers (Bockstael et al., 2013).

A similar trend was identified by D. S. Patel et al. (2010), who found that employees were more likely to engage in safety practices similar to that of their workmates, where a lack of HPD among workmates hindered their own protective behaviours. Bockstael et al. (2012) investigated the extent to which safety climates were able to influence an individual's thoughts and attitudes about noise exposure and HPD use. They used self-reported measures from employees, as well as interviews with safety advisors, across four different companies – in an effort to link HPD usage to company safety climates. Bockstael et al. (2012) found high HPD use was related to stricter non-use procedures and that risk perception was highest in the company with the highest noise levels. Worker attitudes and beliefs were not distinctly different between companies, which Bockstael et al. (2012) suggested was possibly because of the variability of HPDs available in each company.

In an 18-year longitudinal study on noise exposure among lumber mill workers, Davies et al. (2008) concluded that without the implementation of engineering controls, workers who wore HPDs still remained at risk of noise exposure when working around high levels of noise (Davies et al., 2008). These studies emphasise that a holistic approach including all three elements of an HCP is fundamental for the prevention of noise exposure. Furthermore, these studies highlight that employers need to take more responsibility in the promotion of health-related behaviour. Given that several factors can lower the attenuation of HPDs, and that both environmental and individual barriers can hinder HPD use among workers, it is therefore vital that HCPs do not rely solely on the protection component to ensure the safety of workers' hearing.

1.4.4.3 Risk perception.

Knowledge about the risk of noise exposure and possible harmfulness of exposure levels in the workplace can also influence how individuals participate in HCPs (Arezes & Miguel, 2006; Bockstael et al., 2013; Reddy et al., 2012). Low rates of HPD use can be associated with the fact that the risks of NIHI are seemingly invisible and not overtly dangerous (Arezes & Miguel, 2002, 2005).

Arezes and Miguel (2006) used questionnaires to investigate risk perception and HPD use among 434 industrial workers. They identified self-efficacy as the biggest predictor for the use of HPDs, a finding supported by Bockstael et al. (2013), based on scores related to HPD use and risk perception. Self-efficacy refers to a person's belief in his/her capability to successfully perform a particular task (Bandura, 1977). Arezes and Miguel (2006) suggested the scores indicated workers were not familiar enough with the proper fitting and use of HPDs. In line with Arezes and Miguel (2006), Berger (2005) argued that education and motivation are fundamental aspects of HPD use.

1.4.5 The Health Promotion Model.

Complimentary to the earlier Health Belief Model (HBM) developed in the 1950s by Rosenstock and colleagues; the Health Promotion Model (HPM) was developed by Pender (1987). It was based on the same underlying theory to the HBM, namely social cognitive theory, which relates to the interactions between thoughts (cognition) and other personal factors, behaviour, and environmental influences (Bandura, 1989).

The HPM consists of three components that can be used to determine the outcome of a health-promoting behaviour. The first component is characteristics and experiences, which encompass the concepts of prior related behaviour and personal factors such as age, personality structure, and ethnicity (Pender, Murdaugh, & Parsons, 2011). The second component is behaviour specific cognitions and affect, which encompasses eight concepts: (1) perceived benefits of action: the anticipated positive outcomes associated with a health-related action, (2) perceived barriers to action: cost associated with undertaking a health-related action, (3) perceived self-efficacy: the confidence in one's ability to successfully undertake a health-related action, (4) activity-related affect: the emotions felt prior to, during, and after a health-related behaviour, (5) interpersonal influences: the influence of family, peers, and providers, (6) situational differences: the perceived compatibility of life or the environment with engaging in a health-related behaviour, (7) commitment of plan to action: the intentions and strategies the individual has to successfully undertake a health-related action, and (8) immediate competing demands and preferences:

interfering behaviours that provide alternative courses of action prior to the intended health-related behaviour (Pender et al., 2011). The final component is the health-promoting behaviour and the desired endpoint of health-related decision making (Pender et al., 2011).

1.4.6 Health promotion and noise-induced hearing impairment.

The HPM highlights that there are numerous factors that can influence the outcome of health-related actions. HPD use is an example of a health-related behaviour that is controlled by the individual (Lusk, Ronis, & Hogan, 1997) and therefore requires long-term support from a purposely-designed HCP. Several studies have used the HPM to investigate the use of HPDs in different industries (Lusk, Kerr, Ronis, & Eakin, 2009; Lusk et al., 1994; C. M. Stephenson & Stephenson, 2011; M. R. Stephenson, Shaw, Stephenson, & Graydon, 2011). Their findings support the use of the HPM as an evaluation tool for the purpose of tailored educational programs.

Lusk et al. (1994) used an adapted version of the HPM to investigate HPD use among 645 automotive factory workers. The HPM related well to the findings and accounted for 53% of the variance in the use of HPDs. Among the factors that had a positive influence on HPD use were benefits to action, low perceived barriers, and high self-efficacy (Lusk et al., 1994). In a further study by Lusk et al. (1997), the same three factors were found to predict HPD use among construction workers. Furthermore, the authors identified modifying factors on HPD use, namely interpersonal modelling, as a significant predictor of HPD use (Lusk et al., 1997). Interpersonal modelling is a similar concept to that of subjective norms described in section 1.4.4.2, where, in the context of hearing protection, employees are more likely to use HPDs if their co-workers wear HPDs. The authors also found a significant effect for a subjective measure indexing the level of noise exposure, where employees who perceived higher levels of noise exposure were more likely to use HPDs (Lusk et al., 1997).

Lusk et al. (2009) used a questionnaire based on the components of the HPM to determine factors that influenced HPD use among workers. Higher self-efficacy, higher perceived value of use, lower perceived barriers to use, greater perceived exposure to noise, and higher perceived modelling of use were all identified as significant predictors of HPD use. The authors then tailored a video training program to address the specific needs of that group however; the results of the program were not published in the 2009 study. Although the benefits of the training program were not identified, the idea of tailoring material for employees is a promising concept as it has the ability to continuously adapt to the needs of an employee or group of employees.

With the support of NIOSH, C. M. Stephenson and Stephenson (2011) developed a HCP for the construction industry. The first phase of their research involved investigating factors that affect hearing health in the workplace. This was achieved with the help of NIOSH, among other organisations affiliated with the construction industry, who conducted interviews, focus groups, and conferences (C. M. Stephenson & Stephenson, 2011). The authors found that the resulting factors could not be explained by a single health promotion theory. Thus, they combined the HBM, Pender's HPM (Pender, 1987), the Theory of Reasoned Action (Ajzen & Fishbein, 1977) and the Stages of Change Theory (Prochaska, DiClemente, & Norcross, 1992).

The resulting training program was based on the following constructs: (1) perceived susceptibility, (2) perceived severity, (3) perceived benefits of preventive action, including HPD use and hearing monitoring, (4) perceived barriers to preventative actions, (5) self-efficacy associated with HPD selection, fit and use, (6) social norms (safety climate) associated with hearing loss prevention within a construction setting, and (7) behavioural intentions (C. M. Stephenson & Stephenson, 2011). As well as the inclusion of these constructs, the messages in the training program were developed using the Health Communication Theory, which suggests that gain-framed messages, such the authors' example: "wear hearing protection and keep your hearing and quality of life" (C. M. Stephenson & Stephenson, 2011, p. 114) are better at promoting preventative behaviours than loss-framed messages (e.g., not wearing hearing protection will cause a hearing impairment).

The resulting training program included a PowerPoint presentation with videos, alongside an interactive discussion lead by an instructor, as well as a skill mastery session. In conjunction with the training program, participants underwent monitoring audiometry and were given access to a wide range of HPDs to address barriers associated with their use. The training program included a year 1 and year 2 phases over two years. To evaluate the effectiveness of this training program, NIOSH developed a 28-point survey that directly assessed the constructs by determining the level of agreement or disagreement on a Likert scale for statements related to the constructs (C. M. Stephenson & Stephenson, 2011). The results of the training program were presented in a further study by M. R. Stephenson et al. (2011).

M. R. Stephenson et al. (2011) reported an age affect among participants, whose ages ranged from 19 to 50 years, where older participants were more likely to adopt positive beliefs surrounding the comfort of HPDs ($p = 0.044$) and positive behavioural intentions ($p = 0.031$) (M. R. Stephenson et al., 2011). The authors suggested that the presenters of the training content, who were all aged over 50 years, may have influenced older participants. The training program was found to positively influence participants' attitudes and beliefs surrounding beliefs and self-efficacy. Prior to participation in the training program, 45% participants lacked self-efficacy associated with HPD use, while at the end of the study 94% of participants felt they could use HPDs to protect their hearing as well as instruct others on HPD use (M. R. Stephenson et al., 2011). The program also significantly influenced the intentions of participations with regard to HPD use ($P < 0.05$), where 54% of participants reported intentions to use HPDs prior to the training program in comparison to while 70% after the year 2 phase of the training program (M. R. Stephenson et al., 2011).

The authors suggested that their theoretical perspective and well-tested training content was responsible for the marked improvement to barriers and self-efficacy among participants (M. R. Stephenson et al., 2011). They argued that education and training must be designed to positively influence behaviour and that, in order to promote HPD use, workers must first understand the severity of the risks and the benefits to preventative action (M. R. Stephenson et al., 2011). They suggest training should focus on addressing the barriers to HPD use and improving self-efficacy, but should be specifically tailored to the target audience (M. R. Stephenson et al., 2011).

1.5 Health Education

According to Lipscomb (2005b), education is a essential part of HCPs. In the OSHA guidelines, employees who are exposed to a daily TWA at and above 85 dBA (within the permissible limits) should take part in annual education programs. Lipscomb (2005b) argued that successful HCPs require both management cooperation and worker cooperation. However, the content of educational material can be variable and include: seminars, digital presentations, print-based information, computer-based training, and interviews, as well as education by negative (reprimand employees for poor safety compliance), and positive (demonstration and encouragement of safety regulations) example within the workplace. HCPs involving printed or written educational material, such as learning booklets, brochures, and computer tasks, assume adequate reading and literacy levels among employees (Lipscomb, 2005b). For employees with low levels of health literacy, the ability to cooperate will be hindered.

1.5.1 Health literacy.

Health literacy refers to an individual's ability to access, process, and understand both written and numerical health information in order to make informed health-related decisions and improve health-related outcomes (American Medical Association, 1999; Badarudeen & Sabharwal, 2010; Ferguson, 2011; Institute of Medicine, 2004; Narwani et al., 2015; Paasche-Orlow, Parker, Gazmararian, Nielsen-Bohlman, & Rudd, 2005; Safeer & Keenan, 2005; Torpy, 2011; Walsh & Volsko, 2008; Ward-Smith, 2012). Health literacy also includes the ability to use previously learnt information in order to positively impact on health (Benyon, 2014), and is a strong predictor of an individual's health status (Badarudeen & Sabharwal, 2010; Eloy et al., 2012; McInnes & Haglund, 2011). A functional level of literacy is the ability to speak, read, and write at a level of proficiency necessary to function in everyday life (McInnes & Haglund, 2011; Nutbeam, 2008). According to adult literacy survey data, the average reading level of adults in the US and the United Kingdom (UK) is between a 7th or 8th reading grade level (RGL), equivalent to a 13 – 14 year old with up to eight years of education (National Center for Education Statistics, 2003; UK Department for Business Inovation & Skills, 2011). Functional literacy enables people to take control of every day events and health-related decision making, as well as participate both economically and socially in society (Friedman &

Hoffman-Goetz, 2006; Nutbeam, 2008). Functional literacy within health is becoming a more vital skill, where the level of health services and treatment choices has vastly improved alongside a global ageing population (Cheng & Dunn, 2015).

1.5.2 Low health literacy.

In contrast, functional illiteracy is the inability to read, write and calculate for one's own, and the community's development (Vágvölgyi, Coldea, Dresler, Schrader, & Nuerk, 2016). Functional illiteracy is the inability to read above a fifth-grade level (Ayzengart, 2016; McInnes & Haglund, 2011). Low health literacy acts as a barrier to people accessing and understanding important health information (Nutbeam, 2008). It is associated with a number of negative outcomes including: lower use of preventative health interventions (Gazmararian, Parker, & Baker, 1999; Scott, Gazmararian, Williams, & Baker, 2002), increased levels of hospitalisation (Baker et al., 2002), misunderstanding of medication and self-care instructions (Baker et al., 1996; M. V. Williams et al., 1995), poorer general health outcomes and higher mortality rates (Berkman et al., 2011).

1.5.3 Predictors of low health literacy.

Several factors are said to predict low health literacy including: age, level of education, socioeconomic status, ethnicity, and level of income (Benyon, 2014; Ferguson, 2011; Lytton, 2013; Nutbeam, 2008; Safeer & Keenan, 2005). These findings have been supported by two large-scale literacy surveys conducted in the US.

The National Center for Education Statistics (1993) conducted the (American) National Adult Literacy Survey (NALS), which involved 26,000 adults over 16 years of age. The survey identified 21-23% of the population as being a level one literacy category, the lowest of five, which according to Safeer and Keenan (2005), corresponds to a RGL at, and below, fifth grade. Within the level one category, 25% were immigrants who were learning or had low levels of English, while 62% had not completed a high school education (National Center for Education Statistics, 1993). Furthermore, one-third of the level one population was aged 65 years or older, one-third had some form of impairment that prevented them participating in daily activities such as work or school, and 19% had a visual impairment that prevented them from reading print.

Among respondents in the level one category, 66-75% did not regard themselves as having low literacy stating they could read and write “well” or “very well” (National Center for Education Statistics, 1993, p. xvii). Given that the report identified respondents who spoke low levels of English, or had impairments that hindered their ability to answer questions, it is likely that at least some of the 66-75% misunderstood the question. Therefore, the response given may not have accurately reflected their feelings about their literacy sills. Moreover, adults aged 55 years and older were more likely than participants aged 40 to 54 years old, and participants in the younger age groups, to demonstrate limited literacy skills. This is likely due to the finding that, on average, adults aged over 55 years of age had completed fewer years of schooling (National Center for Education Statistics, 1993). However, the effects of low health literacy among adults are exacerbated by poor cognition, vision and hearing, which can affect the ability to read and comprehend health information (Safeer & Keenan, 2005). Ethnic minority populations including Black, American Indian/Alaskan Native, Hispanic, and Asian/Pacific Islander adults were more likely than White adults to perform within the lowest, two literacy levels (National Center for Education Statistics, 1993). Respondents with lower socioeconomic statuses were more likely to demonstrate lower levels of health literacy. Furthermore, on average, male and female respondents performed similarly across the tasks (National Center for Education Statistics, 1993).

A decade later, the National Center for Education Statistics (2003) conducted the (American) National Assessment of Adult Literacy (NAAL). In contrast to the literacy levels used in the NALS, the NAAL used performance indicators that were comprised of: below basic, basic, intermediate, and proficient scales – to describe literacy. The survey identified 22% respondents had basic health literacy, and 14% of respondents scored below basic for health literacy. In contrast to the NALS, women scored higher than men overall (National Center for Education Statistics, 2003). Similar low literacy rates have been reported among the adults in the UK. According to the UK Department for Business Inovation & Skills (2011), one-in-six adults in the UK have literacy levels below a 5^{th} RGL. Much like the NALS, ethnic minorities, respondents for whom English was a second language, adults over 65 years of age, and those living below the poverty line all scored lower than their counterparts.

These findings are relevant to the current study as its focus is on the accessibility of health information, which ties in with the health literacy levels of a given population. As mentioned previously, NIHI has historically affected more males than females, as the sectors in which noise exposure is hazardous, have been dominated by male workers (Nelson et al., 2005). Given that NIHI typically develops over a long history of exposure, it can be expected that individuals with a greater history of exposure are more likely to have NIHI. Low health literacy among older workers could hinder their ability to participate in HCPs, cause problems in understanding paperwork, and hinder access to treatment or compensation associated with NIHI.

Based on the findings from the NALS and NAAL, the recommended 6th RGL for written healthcare information is, in fact, too high for many individuals and does not ensure healthcare information is accessible to the majority of the population. While the recommendations exist, most health-related content is written at, and above, RGLs of 10 (Safeer & Keenan, 2005). Based on the NALS, this means that at least 79% of the population (in the US) has difficulty reading health-related content. The consequences of this, previously mentioned in section 1.5.2, include a lack of understanding, and the need for further explanation from, and reliance on, medical professionals (Ferguson, 2011), and may include friends and family members in an effort to aid decision-making. Furthermore, recognising patients with low health literacy is often underestimated by healthcare workers (Bass, Wilson, Griffith, & Barnett, 2002). Simply identifying the highest level of education achieved by an individual does not predict the level of literacy (Safeer & Keenan, 2005; Vágvölgyi et al., 2016; Ward-Smith, 2012).

1.5.4 Measuring health literacy.

There are several standardised assessments that can measure health literacy among adults. The Rapid Estimate of Adult Literacy in Medicine (REALM) is a reading test to measure literacy levels (T. C. Davis et al., 1993). The REALM measures literacy in RGL based on a patient's ability to read 66 medical terms aloud, as they increase in syllable count and become more difficult to pronounce (Badarudeen & Sabharwal, 2010). The REALM can be completed in a few minutes and has been validated against other health literacy measures. However, it only assesses the pronunciation, not the comprehension of medical terminology, and can only be used on people who are proficient in English (Badarudeen & Sabharwal, 2010). Therefore, the REALM cannot be used on at least 25% of those identified as having low literacy in the NALS.

The Test of Functional Health Literacy in Adults (TOFHLA) is a two-part assessment where the first part involves multi-choice questions relating to medical information, such as pill bottle instructions (Parker, Baker, Williams, & Nurss, 1995). The second part involves a fill-in-the-blank task where individuals are presented with an incomplete sentence and required to choose the most appropriate word (also called the Cloze technique). The TOFHLA takes approximately 20 minutes to complete and the results provide a more in-depth analysis than shorter tests (Parker et al., 1995). Therefore, it is often only used for research purposes (Badarudeen & Sabharwal, 2010). A shortened version of the TOFHLA, called the s-TOFHLA, exists with fewer questions in each of the two parts and requires less time (approximately 8 minutes) than the former.

The Newest Vital Sign (NVS) can also be used to measure literacy among both English and Spanish speakers (Weiss et al., 2005). For this test, patients are presented with a nutritional label from an ice cream container, specifically designed for the NVS. An examiner then asks the patient a series of six questions pertaining to the label and the individual is scored out of six on their performance, where results predict possible literacy levels.

Unfortunately, the health literacy levels of patients who seek health-related information from their computers cannot be taken into consideration by search engines or websites. This means that online health-related information needs to maintain RGLs that accommodate the health literacy levels of its target population (Badarudeen & Sabharwal, 2010), or the health literacy levels of the target population need to be improved.

1.5.5 Improving health literacy.

The objective of improving health literacy is to ultimately improve health outcomes (Raynor, 2012). Freedman et al. (2009) argued that health literacy is not just an individual-level construct; rather, it is a public-level construct that has social, ecologic, and systematic impacts on health and well-being, where efforts to remediate low health literacy has typically focused on the individual and improving interpersonal communication strategies. As discussed in section 1.5.3, age, level of education, socioeconomic status, ethnicity, and level of income are all predictors of low health literacy (National Center for Education Statistics, 1993, 2003). For those individuals, barriers including accessibility to healthcare, as well as time constraints and financial barriers may be more important than low health literacy to overcome. It is therefore important that efforts to remediate low health literacy should focus on the public-level construct, rather than the individual.

In response to the WHO's Commission Report (2007), which stated that the removal of barriers to education will improve health outcomes, Nutbeam (2008) suggested that improving access to education was a way to remediate low health literacy. However, for individuals who identify with the predicting factors of low health literacy, improving education is an unlikely scenario if their health is already compromised. Nutbeam (2008) also suggested the healthcare system can address the effects of low health literacy. This can be achieved by improving the quality of communication by healthcare providers to their patients, as well as improving the current understanding of the impacts of low health literacy on individuals and the population (Nutbeam, 2008; Safeer & Keenan, 2005). Nutbeam (2008) discussed his adaptation of the National (US) Institute of Medicine's health literacy model, which conceptualised a pathway of improvement for low health literacy by healthcare providers. A simplified version is presented in Figure 1. The focus of the current study surrounds the fourth step (outlined in bold). In order to alter information for the benefit of an individual or population with low health literacy, an examination of the readability (defined later in section 1.6.1.) would have to take place.

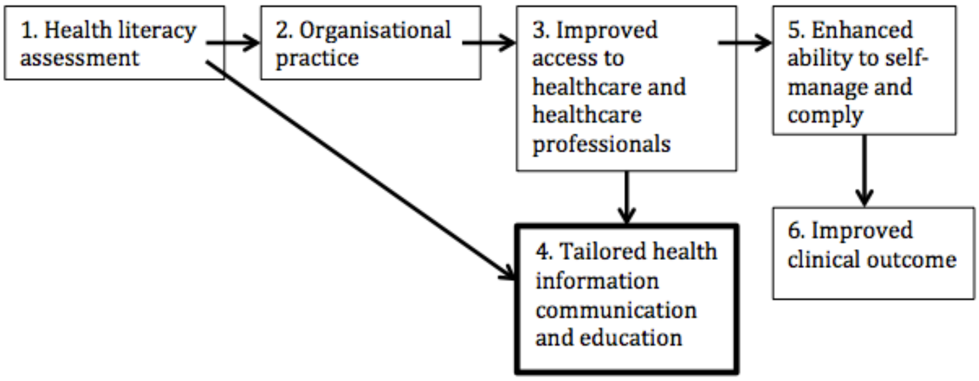


Figure 1. Conceptual model of health literacy as a risk (adapted from Institute of Medicine, 2004; Nutbeam, 2008).

1.6 Online Health Information

Increased Internet use worldwide has changed the way consumers seek health information (McInnes & Haglund, 2011). According to the International Telecommunication Union (ITU) 47% of the global population and 81% of the world's developed population use the Internet (International Telecommunication Union, 2016). Given that the Internet is so widely used, it is not surprising that it is a resource for health-related information seeking (Fox, 2011; Hesse et al., 2005; Shuyler & Knight, 2003). After email and search engine use, accessing health information is the most common Internet activity (Fox, 2011). The Internet enables people to research and explore ways to self-manage health issues as well as aiding health-related decisions (Benyon, 2014; Cheng & Dunn, 2015; Shuyler & Knight, 2003). It is available 24/7, it is cost-effective (in comparison to seeking medical treatment or advice), and is regarded as a source that maintains consumer privacy

(McInnes & Haglund, 2011; Ybarra & Eaton, 2005). However, navigating the Internet relies on a consumer's ability to read, comprehend and assess the reliability of its vast catalogue of information (Benyon, 2014; Eloy et al., 2012; Lytton, 2013; Walsh & Volsko, 2008).

The National Cancer Institute conducted the Health Information National Trends Survey (HINTS) on 6,369 people via telephone from 2002-2003, in order to investigate health-related Internet use (Hesse et al., 2005). The HINTS reported that 63.7% of people use the Internet to search health-related information, with women, whites, and those with higher education and income more likely to do so (Hesse et al., 2005). The HINTS also reported on trust levels associated with the Internet and other health-related information sources. Interestingly, adults aged 18-34 years were more than 10 times likely and adults aged 35-64 years were more than five times as likely, to report trust in the Internet in comparison to adults aged 65 years and over. Higher levels of education were also found to increase Internet trust levels (Hesse et al., 2005).

Several years later, the Pew Internet Project and the California HealthCare Foundation conducted a telephone survey involving 3,001 participants over the age of 18 (Fox, 2011). They reported a similar estimate for Internet use to the HINTS, where 59% of all adults in the US were said to use the Internet for health-related searches (Fox, 2011). Those more likely to use the Internet for health advice included adults providing care for a relative or friend, women, whites, adults between the ages of 18-49, adults with some college education, and adults living in higher income households (Fox, 2011). While African American adults, Latino adults, adults with a disability (including 9% who reported a HI), adults aged 65 and over, adults with a high school education or less, and adults living in lower-income households were less-than half as likely to do the same (Fox, 2011). However, an increase in the use of mobile devices saw a rise in health-related Internet searches among young people, African Americans, and Latino people (Fox, 2011).

While research on Internet use and HI is limited, a recent study by Peddie (2016) on Internet use among adults with HI reported that the majority of participants had used the Internet for HI-related searches, in particular, to explore treatment options. Interestingly, participants in this study reported varying reasons for why they trusted websites. Websites affiliated with known organisations, of a local origin, with a clear layout and large font, and free from commercial entities gained greater trust among participants (Peddie, 2016). These findings highlight the need for quality regulations for health-related material on the Internet, as there is a lack of awareness among consumers about the quality of Internet-based information.

In 2002, the European Commission set out to develop Quality Criteria for Health-Related Websites based on the use of the Internet as a search tool for health-related information. The six criteria included: “transparency and honesty, authority, privacy and data protection, updating of information, accountability, responsible partnering, editorial policy”, and “accessibility” (European Commission, 2002, p. 74). Accessibility encompasses the notions of: “findability, searchability, useability” and “readability” (European Commission, 2002, p. 74) as ways in which health-related material can be made more accessible to consumers, particularly for those with low health literacy (European Commission, 2002; McInnes & Haglund, 2011). When the criteria were issued, among other tasks, it was expected that national and regional health authorities, relevant professional associations, and private medical website owners would implement the criteria to their websites (European Commission, 2002). Under the accessibility criteria, this would include improving the readability of

European top-level domain (TLD) health-related websites. However, information in the following section indicates this is not the case.

1.6.1 Readability of online health information.

Health literacy involves the ability to not only read health information but comprehend it as well. Readability is related to comprehension and refers to the ease in which a piece of written information can be read and understood by an individual (Badarudeen & Sabharwal, 2010; Cheng & Dunn, 2015; Eloy et al., 2012; McInnes & Haglund, 2011; Narwani et al., 2015). Readability is typically measured and represented by Western education RGLs. It is widely recommended that health-related materials be written at or below a 6th RGL in order to improve comprehension and compliance (American Medical Association, 1999; Badarudeen & Sabharwal, 2010; Ferguson, 2011; National Library of Medicine, 2013; Safeer & Keenan, 2005; Walsh & Volsko, 2008). A 6th RGL is equivalent to an 11-12 year old with six years of education (Fitzsimmons, Michael, Hulley, & Scott, 2010). As well as lower RGLs, Safeer and Keenan (2005) suggest that patient-targeted health material should include pictures and illustrations to aid understanding. However, several studies have demonstrated that a large variety of web based health-related consumer information exceeds these recommendations (Cheng & Dunn, 2015; Eloy et al., 2012; McInnes & Haglund, 2011; Misra et al., 2012; Narwani et al., 2015; C. R. Patel et al., 2015; Walsh & Volsko, 2008). Among the readability studies listed above, three examined the readability of web-based material across a broad-range of health topics are discussed further below.

Walsh and Volsko (2008) examined the readability of 100 randomly-chosen, web-based articles from organisations for five common health conditions in the US. They used three readability assessment tools: Gunning FOG (Frequency of

Gobbledygook) (Gunning, 1952), the Simple Measure Of Gobbledygook (SMOG) (McLaughlin, 1969), and Flesch-Kincaid (F-K) (Kincaid, Fishburne, Rogers, & Chissom, 1975). Articles were subsequently categorised from easiest to most difficult to read, using the US Department of Health and Human Services readability categories (Walsh & Volsko, 2008). Mean RGLs for the 100 articles were 11.80, 9.85, and 13.10 for SMOG, F-K, and Gunning FOG respectively (Walsh & Volsko, 2008). While the authors could have used Flesch Reading Ease (FRE) in place of the USDHHS' readability categories to investigate how well the scores correlated across formulas, as well as a lower comparative RGL than the 7th RGL for their analysis, their results still demonstrated that the mean RGLs of web-based information exceed the recommendations.

McInnes and Haglund (2011) investigated the readability of webpages related to searches on 22 different health conditions. They used four readability assessment tools: Gunning FOG, SMOG, F-K, and Flesch Reading Ease (FRE) (McInnes & Haglund, 2011). After analysing 352 websites, they identified the mean RGL was 12.30 and mean FRE score was 46.08, a score considered difficult with regards to reading ease, and not one website in the study met the recommended 5th – 6th RGL (McInnes & Haglund, 2011). Additionally, the authors identified that complex search terms elicited significantly higher readability scores ($p < 0.001$) than simple terms. For example, the search term "MDD" (major depressive disease), resulted in webpages with significantly higher RGLs than "depression" (McInnes & Haglund, 2011, p. 181). The study also found that webpages with .gov and .nhs TLDs had lower (better) RGLs than .edu TLDs. Furthermore, Wikipedia webpages were significantly harder to read than other .org TLD webpages ($p < 0.001$), with mean RGLs of 15.21 and FRE scores of 31.22, denoting them very difficult to read. When

Wikipedia webpages were removed from the .org TLD analysis, the mean RGL decreased to 11.75 and the mean FRE score to fairly difficult, showing that with or without Wikipedia webpages included in the analysis, the readability was still far above the recommended levels. While the authors increased the reliability of their results by opting to use multiple readability formulas, they combined the four means and presented the scores as a single mean RGL; therefore limiting their findings for future comparisons.

A similar methodology to McInnes and Haglund (2011) was adopted by Cheng and Dunn (2015), who performed an analysis of the readability of Australian health-related websites using three readability assessment tools: F-K (Kincaid et al., 1975), FRE (FRE; Flesch, 1948) and SMOG (McLaughlin, 1969). They identified mean RGLs for F-K and SMOG as 10.54 and 12.12 respectively, and a mean FRE score of 47.54; a score considered difficult with regards to reading ease. The authors used an 8^{th} RGL benchmark for comparison from a local government health body instead of the recommended 6^{th} RGL. This was due to inconclusive research data on the health literacy levels for the Australian population (Cheng & Dunn, 2015). Although their RGL threshold was higher, their results still showed that the readability of health-related information was too high for much of the population. The authors suggested the need for “quantifiable guidelines” for online health-related information, such as those published by the European Commission, to ensure it is accessible to the population (Cheng & Dunn, 2015, p. 313).

Researchers have also investigated the readability of health information related to HI (Atcherson et al., 2014; Laplante-Lévesque et al., 2012; Potter, 2015). Atcherson et al. (2014) investigated the readability of 225 audiology and speech-language-pathology related articles available on the American Speech-language

Hearing Association's (ASHA) website. They used four readability formulas including FRE, F-K, Gunning FOG, and FORCAST (Caylor, Sticht, Fox, & Ford, 1975), to measure readability. For audiology articles prior to 2011, where audiology-related materials on ASHAs website underwent a remodelling to improve readability, the study found a mean RGL of 11.2 across the four readability formulas used (Atcherson et al., 2014). In comparison, for audiology-related articles after 2011, the mean RGL was 10.5, which remained high but showed a small improvement (Atcherson et al., 2014). ASHA is an organisation whose vision involves accessible communication. However, consumer-directed audiology information on its website showed RGLs higher than the recommended 6th grade levels, therefore making it inaccessible to many individuals.

Low levels of readability were also reported in Laplante-Lévesque et al. (2012), who analysed the readability of 66 websites retrieved using keyword searches related to HI. They found a mean FRE score of 48.26, while F-K, and SMOG had mean RGLs of 11.10 and 12.36 respectively (Laplante-Lévesque et al., 2012). Furthermore, Potter (2015) drew from the methodologies of Laplante-Lévesque et al. (2012) and analysed web-based material related to HI using the New Zealand Google ccTLD. In line with the previous studies, Potter (2015) reported low rates of readability using three readability measures, specifically, mean RGLs of 12.32 and 13.24 for F-K and SMOG, and a mean FRE score of 42.98; again corresponding to a difficult-to-read score.

The above studies report on the readability levels of web-based information across a wide range of health conditions, including a limited amount of research related to HI. While readability varies across individual articles, the mean readability measured by the several different formulas in each of the above studies far exceeds the recommended 6th grade levels. The readability formulas used in the studies are widely used for the assessment of health-related material. As such, the results from these studies make for good comparative literature for future studies that seek to investigate readability. Although none of the studies were directly related to NIHI, the current study implements a similar methodology, in particular to Laplante-Lévesque et al. (2012) and will therefore draw comparisons to the findings in chapter 4.

1.6.2 Quality of online health information.

The US National Institute on Aging (NIA) highlighted that a common concern among older adults is whether health information on the Internet is trustworthy (National Institute of Aging, 2014). There are suggestions that government agencies, large professional organisations, and well-known medical schools are good sources of information (National Institute of Aging, 2014; Torpy, 2011). However good information does not necessarily mean good quality. Google is the most popular search engine with over 80% of the global market share (Net Marketshare, 2017) and therefore, more likely to be the starting point of many health-related searches. According to Ahmed, Sullivan, Schneiders, and McCrory (2012) there is no generic tool for evaluating health-related websites. Consequently, the content of health-related websites remains largely unregulated.

One way of assessing webpage quality is whether it is Health On the Net (HON) certified. HON is a Swiss-based non-profit organisation aimed at guiding consumers toward quality information and was founded in 1995. In order to obtain a HON certification, a website must abide by eight principles: authoritative, complementary, privacy, attribution, justifiability, transparency, financial disclosure, and advertising policy (Health On the Net [HON], 1995). In short, a website must indicate the qualifications of the authors, provide information that supports of the doctor-patient relationship, respect the privacy and confidentiality of anything relating to the consumer, cite the source(s) of published information and date medical and health pages, ensure accessibility of presentation and provide accurate email contact(s), identify funding sources, and clearly distinguish advertising from editorial content (HON, 1995).

Unfortunately, HON certification among hearing-related websites is low. Laplante-Lévesque et al. (2012) examined the quality of online information related to HI using two measures including HON. They reported that less than 14% of webpages were HON certified. While websites of a commercial origin made up 64% of the sample, those of a government origin (15% of the sample) were more likely than non-profit (21% of the sample) and commercial to have a HON certification (Laplante-Lévesque et al., 2012). Furthermore, in an online survey conducted by HON involving 2,621 participants, 29.3% of participants were unfamiliar with quality marks such as the HON certificate (Boyer, Provost, & Baujard, 2002). Therefore, even if certification was more popular across websites, it often goes unrecognised by many consumers.

Quality certifications also exist within particular online organisations. Laurent and Vickers (2009) sourced keywords from the websites: MedlinePlus, NHS Direct Online, and the National Organization of Rare Diseases and then recorded the Google search results using these keywords. English Wikipedia (https://en.wikipedia.org) webpages appeared most frequently in the top position across keyword searches, more so than each of the three medical websites from which the keywords were sourced. Furthermore, English Wikipedia appeared among the top ten websites appearing 71-85% of the time across keyword searches (Laurent & Vickers, 2009). This is a similar finding to McInnes and Haglund (2011) who identified Wikipedia webpages as the most frequently-appearing webpages among search results. While Wikipedia is a user-edited online resource, English-language Wikipedia articles can undergo a quality assessment by those knowledgeable in the field. Within the rating scale, only two levels of quality may undergo a formal review process, namely “featured” and “good” articles, which Laurent and Vickers (2009) collectively name “quality articles” for the purpose of their study (Laurent & Vickers, 2009, p. 478). Among the English-language Wikipedia webpages returned using a keyword search, quality articles ranked higher (Laurent & Vickers, 2009). This result is promising for the many consumers who are searching for informative and accurate answers to their health-related questions. However, as the study highlights, regardless of how frequently English-language Wikipedia is returned across keyword searches, the extent to which a consumer relies on its information is not yet established (Laurent & Vickers, 2009). Furthermore, while English-language Wikipedia can include a quality rating, a useful tool for consumers that may encourage consumer trust, this quality rating does not reflect the articles’ quality in terms of its readability and is not available for every article.

Given that Wikipedia has more than 5.3 million articles available in English alone and has articles in 284 different languages (Wikipedia, 2017b) research on the quality and accuracy of its information is important. A study by Clauson, Polen, Kamel Boulos, and Dzenowagis (2008) used a set of drug-related questions to compare information on Wikipedia to WebMD in an effort to assess the webpages’ scope, completeness, and accuracy. They found that Wikipedia was more factually accurate than WebMD, which had four answers that conflicted with the answer key presented among the set of questions, while Wikipedia had none. However, Wikipedia was less complete (76%), in comparison to WebMD (100%), and had a narrower scope, scoring 40% in comparison to WebMD's 100% for answerable questions (Clauson et al., 2008). Heilman et al. (2011) argue that the quality of Wikipedia is hindered by its lack of quality control measures and open approach to editing. They suggest systems such as Flagged Revisions and Pending Changes (Wikipedia, 2017a), where an established editor must approve editing before it is published, should be used for English-language Wikipedia as they are in German, Russian, and Polish-language versions (Heilman et al., 2011). These systems underwent a two-month trial on English-language Wikipedia in 2010, but remain unused even after a consensus to implement them by editors in 2012 (Wikipedia, 2017a).

1.7 Rationale

As previously stated, NIHI is a large, and on-going issue, that has the ability to negatively impact on quality of life outcomes. Furthermore, efforts to prevent of NIHI, including health education, may be hindered by low health literacy levels among worker populations. Research has demonstrated that online health-related information is written at levels that far exceed the 6th RGL recommendations, and lacks quality certifications such as HON. It is therefore important that information pertaining to NIHI and preventative measures associated with NIHI are written at levels that are accessible to worker populations. However, to date, there is no research on the readability or quality of material related to NIHI. Given that the Internet is so widely used among consumers to seek healthcare information, it is relevant that readability investigations should focus on web-based health information. By identifying that materials related to NIHI are written at levels that exceed the recommended levels, hearing conservation and education programs will have a basis for altering their material to improve its readability and quality. As a result, more worker populations will have access to educational material associated with the prevention of NIHI, and individuals will be better equipped to adhere to prevention measures associated with NIHI in the future.

1.8 Aims and Hypotheses

This study aims to investigate the following research questions:

1. What is the readability of online written information associated with searches related to NIHI?
2. Is the readability of webpages related to NIHI significantly higher than the recommended 6th grade levels?
3. Are there significant differences in the readability of NIHI-related online written material from different organisations?
4. Are there significant differences in the readability of NIHI-related online material from different countries?
5. Do NIHL-related webpages present with a HON certification and is this related to country or organisation origin?

Based on the above research questions, five null hypotheses exist for this research:

1. Readability will not be low (difficult to read) among online written information associated with NIHI
2. The readability of webpages related to NIHI will not be significantly higher than the recommended 6th grade levels.
3. There will be no significant difference in readability among webpages from different organisations
4. There will be no significant difference in readability among webpages from different countries

5. There will be no significant interaction between the presence of a HON certificate and webpage origin (organisation and country).

2 Methodology

This study investigated the readability and quality of online written information on noise-induced HI available in English on 26 country-coded top-level domains (ccTLDs) of Google. In order to assess the readability of the written information, the study analysed the first 10 relevant Webpages retrieved on 26 different English-language ccTLDs for five key terms including: “hearing loss claim”, “industrial hearing loss”, “hearing loss noise”, “NIHL”, and “NIHL claims”. Readability was assessed using the Flesch-Kincaid (F-K; Kincaid et al., 1975), Flesch Reading Ease (FRE; Flesch, 1948), and Simple Measure Of Gobbledygook (SMOG; McLaughlin, 1969). The quality of the webpage content was assessed by the presence of a Health On the Net Certificate (HON).

2.1 Internet search

Google Trends is a platform that provides information about how often particular search terms have been queried over a specific period of time. In order to determine key words associated with online searches about noise-induced HI, this researcher performed two searches on the Google Trends platform (www.google.com/trends).

The first search was performed on the 5th September 2016 and used the key phrase “hearing loss”. This search returned one related query, namely, “hearing loss claim”, which was ranked the ninth most popular related query – up 130% in the last five years. The key phrase “hearing loss claim” returned no geographical data or relevant related topics and just one related query, namely, “industrial hearing loss”. A further search on “industrial hearing loss” returned no geographical data, relevant related topics or queries.

The second search, also performed on the 5th of September 2016 used the key phrase “hearing loss noise”. This search returned “NIHL” as a related query, which was ranked the seventh most common related query and up 80% in the last five years. The phrase “hearing loss noise” returned no geographical data. Related queries for “NIHL” included “what is NIHL” and “NIHL claims” which were ranked as the fourth and fifth most common related queries, and were up 400% and 300% over the last five years, respectively. The information from these Google Trends searches identified five key phrases that were used in this study. These included:

1. Hearing loss claim
2. Industrial hearing loss
3. Hearing loss noise
4. NIHL
5. NIHL claims

Due to the lack of specific geographical data available on Google Trends, it was decided that the key phrases would be searched in the top six most populous countries of the six regions of the world where English was an official language or spoken by at least 15% of the population. This information was determined using The Central Intelligence Agency (CIA) World Factbook (Central Intelligence Agency [CIA], 2016) and is outlined in Table 1 (below). World regions were determined by the WHO (WHO, 2017), and included: African Region, Region of the Americas, South-East Asia Region, European Region, Eastern Mediterranean Region, and Western Pacific Region.

Table 1. Top six countries in each of the six world regions where English is an official language or spoken by at least 15% of the population, as sourced from (CIA, 2016).

Country	Google Domain	Population	Region
Nigeria	Google.com.ng	181,562,056	Africa
South Africa	Google.co.za	53,675,563	Africa
Tanzania	Google.co.tz	51,045,882	Africa
Kenya	Google.co.ke	45,925,301	Africa
Uganda	Google.co.ug	37,101,745	Africa
Malawi	Google.mw	17,964,697	Africa
United States	Google.us	321,368,864	Americas
Canada	Google.ca	35,099,836	Americas
Jamaica	Google.com.jm	2,950,210	Americas
Trinidad and Tobago	Google.tt	1,222,363	Americas
Guyana	Google.gy	735,222	Americas
Suriname	Google.sr	579,633	Americas
Pakistan	Google.com.pk	199,085,847	Eastern Mediterranean
United Kingdom	Google.co.uk	64,088,222	Europe
Ireland	Google.ie	4,892,305	Europe
Jersey	Google.je	97,294	Europe
Isle of Man	Google.im	87,545	Europe
Guernsey	Google.gg	66,080	Europe
Gibraltar	Google.com.gi	29,258	Europe
India	Google.co.in	1,251,695,584	South East Asia
Indonesia	Google.co.id	255,993,674	South East Asia
Sri Lanka	Google.lk	22,053,488	South East Asia
Philippines	Google.com.ph	100,998,376	Western Pacific Region
Vietnam	Google.com.vn	94,348,835	Western Pacific Region
Australia	Google.com.au	22,751,014	Western Pacific Region
Papua New Guinea	Google.com.pg	6,672,429	Western Pacific Region
Singapore	Google.com.sg	5,674,472	Western Pacific Region
New Zealand	Google.co.nz	4,438,393	Western Pacific Region

2.1.1 Website inclusion and exclusion criteria.

Websites were included if they provided information relevant information on or about NIHL. Exclusions included paid advertisements, which were denoted by a green flag “Ad” and trends, which were denoted by a shaded box. Videos and directory listings were also excluded, as they could not be analysed using the readability software used in this study.

2.1.2 Search procedure.

For the purpose of this research, the term "website" referred to a website in its entirety, whereas the term "webpage" referred to a specific page on a particular website. This research involved the analysis of webpages, and in some cases, embedded links within those webpages that linked to other additional webpages. Each of the five key phrases was entered into the 26 ccTLDs. The first 10 webpages that met the inclusion criteria were retrieved and the date of search, computer, browser, Uniform Resource Locator (URL) and website origin were recorded (Appendix A). The website organisation origin (commercial, government, non-profit) and country of origin was recorded. The origin was determined by the URL domain name or information sourced from the "contact" or "about us" section of each website, where head office addresses and telephone numbers indicated the origin of the website. The webpage content was then copied and pasted into separate Word documents and saved. Embedded links within the webpages were examined also. If the links were deemed relevant to NIHL, i.e., treatment, symptoms, and jobs where NIHL is a risk, and linked internally to the website, i.e., clicking on an embedded link for symptoms did not take the user to a different, external website, the information was copied into further separate Word documents. Links to academic journal articles were also included in this study. However, only the abstract of each article was copied to a Word document for readability assessment, as most articles required a subscription to access the full article.

2.2 Readability Analysis.

The resulting 153 Word documents were analysed using Readability Studio (Oleander Software, 2012). This software provides information on the readability of the document depending on which readability formulas are selected. The researcher underwent the following steps to determine the readability of the documents:

1. Opened Readability Studio (Oleander Software, 2012) and click on "create new project".
2. Chose English as the document language.
3. Selected a saved Word document.
4. Chose "non-narrative", "fragmented text" under composition, "sentences split by illustrations or extra spacing" and "centered/left-aligned text under document layout.
5. Manually selected F-K, FRE, and SMOG readability formulas.
6. Recorded the resulting readability scores and reported information in Excel for statistical analysis.
7. Steps 1 through 6 were repeated for all website Word documents.

2.2.1 Readability measures.

Three readability formulas were used to assess the readability of the webpage Word documents. These included the F-K, FRE, and SMOG. The Flesch Reading Ease (FRE; Flesch, 1948) calculates the readability of written information by analysing the average syllables per word and the average words per sentence. The FRE Scale Score is calculated based on the analysis of at least three passages of text containing 100 words and ranges from 0 – 100, with a lower score denoting a lower readability. The F-K is a modified version of the FRE formula that produces a United States (US) RGL score for readability instead of the 0 – 100 scoring system of the

FRE formula. It was developed by the US Navy on the premise that it was easier than the FRE for various professionals (healthcare professionals and educators) to evaluate the RGL of written content (Kincaid et al., 1975). Both the FRE and the F-K formulas can determine the readability of written text between Grade 5 and college level (Friedman & Hoffman-Goetz, 2006).

The SMOG predicts readability based on the number of polysyllabic words counted among 30 sentences from the beginning, middle, and end of a passage. The SMOG readability formula differs from the FRE and F-K as it estimates the years of education an individual would need to fully understand a piece of written information (McLaughlin, 1969). The basis for this measure was that written information, in particular of a medical or healthcare origin, should be 100% comprehendible by a patient (Meade & Smith, 1991). Due to its ability to predict comprehension, the SMOG is considered the gold standard for the evaluation of health materials (Cheng & Dunn, 2015). Although it is highly correlated with the FRE (r - .95 to .96) and the F-K (r = .93) z (Cheng & Dunn, 2015; Meade & Smith, 1991), the SMOG typically scores RGL more conservatively in comparison to both the FRE and F-K formulas (Friedman & Hoffman-Goetz, 2006). Together, these three readability formulas are the most commonly used among studies on online health-related information (Cheng & Dunn, 2015).

2.3 Health On the Net Certification

The quality of each website was determined based on the presence of a HON certificate. This was determined by entering the root web address from each website into a HON search (http://www.hon.ch/HONsearch/Patients/index.html). If the website was listed on the HON website then "yes" was recorded and if it was not listed then "no" was recorded.

2.4 Statistical Analysis

There were two independent variables (IVs) in this study. The first IV was organisation with three levels: commercial, governmental, and non-profit. The second IV was country, which initially had 10 levels, and was revised to four levels: Australia, United Kingdom, United States, and Other. The "Other" category included seven countries and was representative of approximately one-quarter of the dataset. The "Other" category was established to ensure a statistical analysis would be possible given the low counts of data from some countries. Likewise, each of the other three levels was representative of approximately one-quarter of the dataset.

Several statistical analyses took place in order to investigate the research questions: descriptive statistics, a one-sample t-test, a two-way multivariate analysis of variance (MANOVA) measure, a two-way analysis of variance (ANOVA) measure, two one-way ANOVA measures, and a Chi-squared test. The statistical analyses were performed using IBM SPSS Statistics software version 23 for Macintosh.

3 Results

3.1 Overview

A total of 153 webpages underwent a readability analysis. The analysis included the first 10 relevant webpages that were generated after searching the five key terms “hearing loss claim”, “industrial hearing loss”, “hearing loss noise”, “NIHL”, and “NIHL claims” in each of the 26 ccTLDs. The initial search totalled 1,300 webpages (5 key phrases x 10 webpages x 26 ccTLDs) and was reduced to 127 when duplicates, and webpages totalling fewer than 100 words were excluded. A further 25 documents generated from the embedded links within the 127 webpages made up the total of 153 webpages analysed. Information about webpage origin (organisation and country) is represented in Tables 2 and 3 (below).

3.2 Webpage Origin

For the purpose of this research, the researcher divided webpage origin into two categories. These were origin by organisation (OO, commercial, government, non-profit) and origin by country (OC, where the website originated from or was based). This information was usually sought from the embedded link “contact” or “contact us” on the home page of each website. The search showed that the majority of webpages were of a commercial OO, followed by OOs that were non-profit, and then OOs that were governmental. With regards to country of origin (CO), the search identified 10 countries of origin across the 26 ccTLDs. The United Kingdom was the most common webpage CO found by the search. Webpages from the United Kingdom were the most frequently occurring webpages in 24 out of 26 ccTLD searches. This was followed by the United States, which also frequently appeared in searches. Only three ccTLDs had country origins that matched their ccTLD and occurred more frequently than other country origins within the search. These were Australia, Canada, and New Zealand, whose webpages were most frequently governmental OOs (Australia and New Zealand) followed by commercial OOs (Canada).

Table 2. Webpage origin by organisation

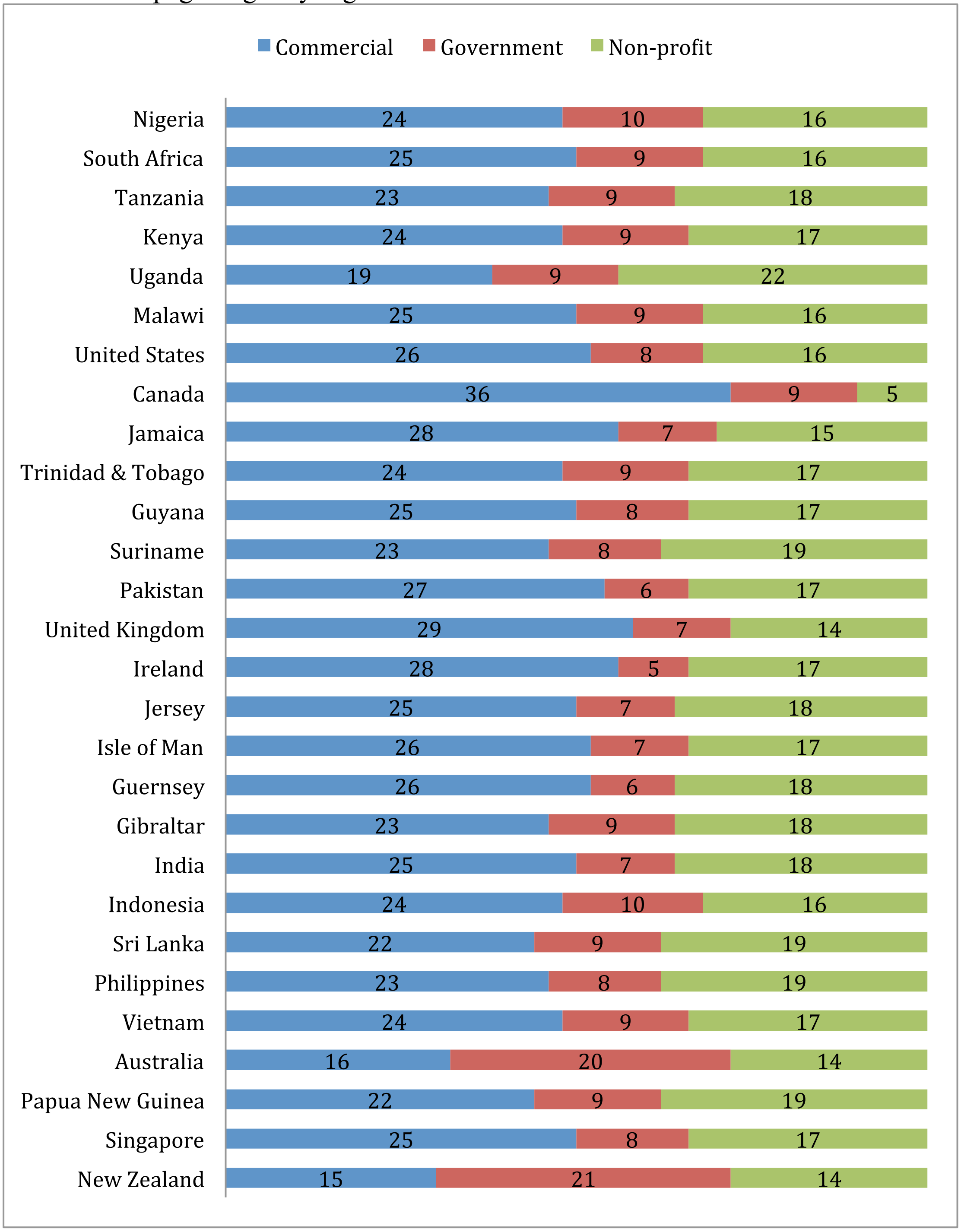
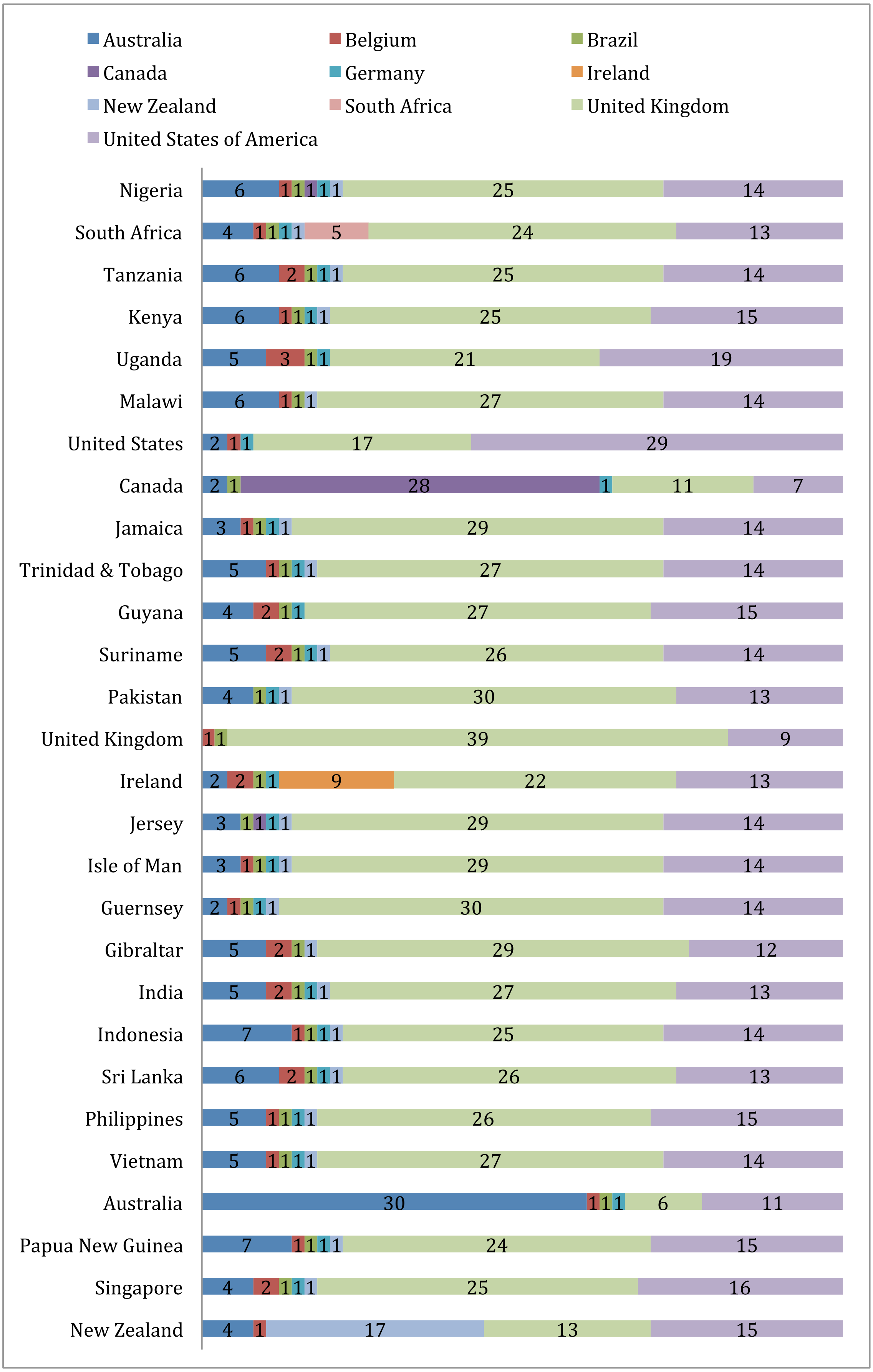


Table 3. Webpage origin by country



3.3 Readability

The websites were analysed using the FRE, F-K, and SMOG readability formulas. The current study aimed to investigate the following research questions related to readability: (1) What is the readability of online written information associated with searches related to NIHI? (2) Is the readability of online information significantly higher than the recommended 6th grade levels? (3) Are there significant differences in the readability of NIHI-related online written material from different organisations? (4) Are there significant differences in the readability of NIHI-related online material from different countries?

Overall, the webpages had significantly-higher readability than the recommended 6th RGL according to one-sample t-tests for F-K $t(152) = 34.90$ $p < 0.001$ and SMOG $t(152) = 55.89$ $p < 0.001$. Not one webpage out of 153 met this grade level recommendation based on the three readability formulas used in the analysis. Among those formulas, where the confidence interval (CI) range is presented in parentheses, the mean readability score for FRE was 40.90 (95%CI = 38.70-42.92), 14.23 (95%CI = 13.75-14.72) for F-K, and 15.4 (95%CI = 15.09-15.78) for SMOG. The lowest readability level was 67 for FRE, 8 for F-K, and a 10.6 for SMOG, where F-K and SMOG correspond to grade levels and the FRE score represents a readability score that corresponds to a US grade-level. In this case, a score of 67 represents a grade-level between 8th and 9th grade. Based on these results, the null hypotheses: Readability will not be low (difficult to read) among online written information associated with NIHI, and the readability of webpages related to NIHI will not be significantly higher than the recommended 6th grade levels, could be rejected. The mean readability scores for each of the three formulas are presented in Table 4 (below).

3.4 Statistical Analysis

3.4.1 Descriptive statistics.

Table 4. Mean readability for the Flesch Reading Ease (FRE), Flesch-Kincaid (F-K), and Simple Measure Of Gobbledygook (SMOG) measures.

			Bootstrap[a]			
					95% Confidence Interval	
		Statistic	Bias	Std. Error	Lower	Upper
FRE	N	153	0	0	153	153
	Min[b]	.0				
	Max[b]	67.0				
	Mean	40.895	-.018	1.081	38.700	42.921
	SD	12.8156	-.0442	.8052	11.2602	14.3164
FK	N	153	0	0	153	153
	Min	8.0				
	Max	19.0				
	Mean	14.232	.002	.243	13.754	14.716
	SD	2.9174	-.0087	.1193	2.6693	3.1290
SMOG	N	153	0	0	153	153
	Min	10.6				
	Max	19.0				
	Mean	15.429	.004	.176	15.088	15.784
	SD	2.0869	-.0051	.0940	1.9008	2.2672

a. Bootstrap results are based on 1000 bootstrap samples
b. The minimum and maximum results for FRE actually represent the highest and lowest readability scores, where a higher FRE score represents better readability.

3.4.2 Analysis of variance.

There were two independent variables (IVs) in this study. The first IV was organisation, with three levels: commercial, government, and non-profit. The second IV was country, with four levels: Australia, United Kingdom, United States, and Other, which included data from Brazil, Belgium, Canada, Germany, India, Ireland,

and New Zealand. There were three dependent variables (DVs) in this study: FRE, F-K and SMOG. The researcher performed a series of analyses to investigate the hypotheses.

With assistance from her supervisors, the researcher performed a two-way multivariate analysis of variance (MANOVA) to determine if there were any significant differences in the set of variables (N = 153). Box's M test of equality of variance was significant ($p < .001$), indicating the homogeneity assumption had been violated. A review of the sample sizes revealed that at least one cell had a sample size of 1 ("non-profit"). Therefore, the researcher removed the non-profit data from the sample to perform the next analysis.

The researcher performed a series of two-way analysis of variance (ANOVA) to determine if there was a significant interaction between the IVs for any of the DVs. The sample size for these analyses was 119 webpages, as it did not include data pertaining to the organisation origin of non-profit. There were no significant interactions for any of the analyses. Therefore, the researcher examined the main effect of organisation (commercial and government) using a one-way ANOVA. The findings from these analyses were:

1. Commercial webpages had significantly higher (better) FRE scores than governmental webpages: $F(1,111) = 6.36$, $p = .013$, $\eta_p^2 = .054$.
2. There was no significant difference in F-K RGL based on organisation: $F(1,111) = 3.81$, $p = .054$, $\eta_p^2 = .033$.
3. Commercial webpages had significantly lower (better) SMOG RGL based on "organisation": $F(1,111) = 4.54$, $p = .034$, $\eta_p^2 = .040$.

Therefore, the null hypothesis: There will be no significant difference in readability among webpages from different organisations, could be rejected based on the readability score dependent variable on the FRE and SMOG measures. However, the null hypothesis was supported for the readability score dependent variable on the F-K readability measure.

The researcher then added the webpages with a non-profit origin back into the analyses to examine the main effect of country. The sample size for these analyses was 153 webpages. The findings from these analyses were:

1. There was no significant difference in FRE based on country: $F(3,149) = 0.12$, $p = .95$, $\eta_p^2 = .002$.
2. There was no significant difference in F-K RGL based on country: $F(3,149) = 1.26$, $p = .29$, $\eta_p^2 = .025$.
3. There was no significant difference in SMOG RGL based on country: $F(3,149) = 0.73$, $p = .53$, $\eta_p^2 = .015$.

Therefore, the null hypotheses: There will be no significant difference in readability among webpages from different countries, could be rejected.

3.4.3 Chi-Squared test for independence.

The fifth research question in this study related to the quality of online information: (5) Do NIHL-related webpages present with a HON certification and is this related to country or organisation origin? The first chi-square test investigated whether there was an interaction between organisation origin (commercial, government, non-profit) and the presence of a HON certification (N = 153). For chi-square tables greater than 2 x 2, the assumption is that no more than 20% of cells will have an expected count of less than five. The analysis found that 3 cells (50%) had an expected count of less than 5, which meant that the assumption was violated. This was because only eight websites (3 commercial, 2 government, 3 non-profit) out of the 153 webpages involved in the analysis had a HON certification. In the case where the assumption was violated, the researcher must use the “likelihood ratio” to determine statistics. This gave a significance value of p = .559, which was not significant. Therefore, the null hypothesis that there was no interaction between organisation origin and the presence of a HON certificate was supported.

The second chi-square test investigated whether there was an interaction between country origin (Australia, USA, UK, Other) and the presence of a HON certification. Five out of eight (62.5%) of the HON certified webpages had a USA CO while three out of eight (37.5%) had a UK CO. The assumption was again violated, due to the overall low number of webpages with HON certification. However, the likelihood ratio gave a significance level of p = .007, which was significant, and suggested that there was an interaction between country origin and the presence of a HON certification. Therefore, the null hypothesis that there was no interaction between country origin and the presence of a HON certificate was rejected.

3.5 Results Summary

The following flow chart (Figure 1) details the statistical analyses performed in 3.4.

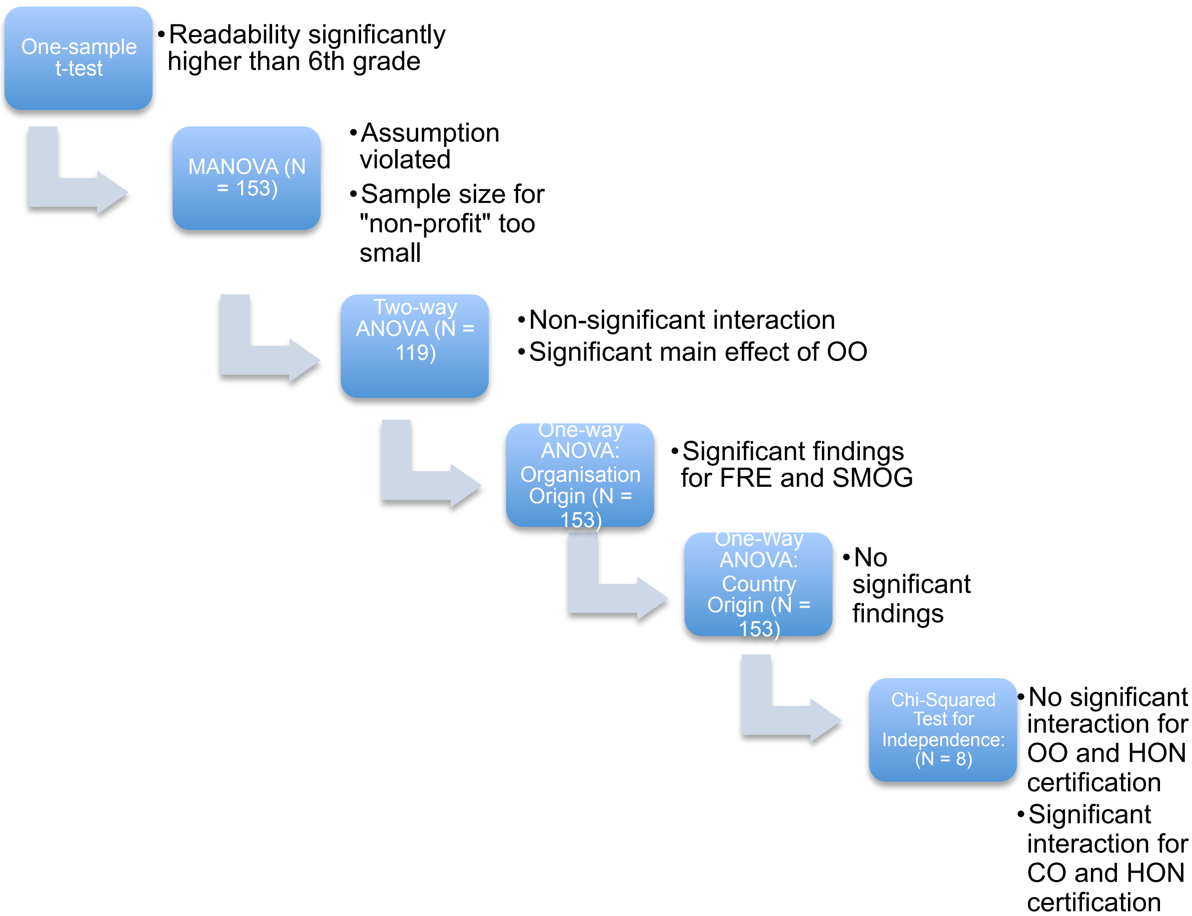


Figure 2. Flow chart of statistical analyses

The null hypotheses for this study were: (1) Readability will not be low (difficult to read) among online written information associated with NIHI, which was supported following a readability analysis where no webpages scored at the recommended 6^{th} RGL for readability. (2) There will be no significant difference in readability among webpages from different organisations, which was rejected following a one-sample t-test. (3) There will be no significant difference in readability among webpages from different organisations, which was which was supported: webpages were not statistically different from government origin webpages for the F-K RGL, and rejected: commercial webpages scored better in terms of readability than governmental webpages on the FRE and SMOG RGL in the analysis in 3.4.2. (4) There will be no significant difference in readability among webpages from different countries, which was supported by the analysis in 3.4.2. (5) There will be no interaction between webpage origin and the presence of a HON certification, which was supported for the OO analysis but not for the CO analysis, which showed a significant interaction between CO and the presence of a HON certification.

4 Discussion

The aim of this study was to determine the readability and quality of online information related to NIHI. The first part involved a readability analysis of 153 webpages that were returned following key word searches related to NIHI derived from Google Trends. The study aimed to answer several questions related to readability. The readability analysis and subsequent statistical analysis indicated that, in general, the readability of online written information associated with NIHI was low and therefore inaccessible for much of the intended audience.

The second part aimed to answer a research question related to the presence of HON certificates among webpages. While the vast majority of webpages in this study did not have a HON certification, there was a significant interaction between country of origin (ccTLD) and the presence of a HON certification. These findings are discussed in comparison to the literature below. Additionally, a discussion of the study's limitations and clinical implications will follow. The last section will include suggestions for future research on the topic of readability and NIHI.

4.1 Readability

4.1.1 Readability levels.

The first research question pertained to the readability levels of online written information associated with NIHI. The current study determined that the readability of online NIHI-related material was high, ranging from grade levels of 14.23 (F-K) to 15.4 (SMOG) and a mean FRE score of 40.90, which corresponds to difficult-to-read text, consistent with a college reading level. These findings are in agreement with other studies that evaluated the readability of online material using similar readability formulas as employed in the current study.

For example, Walsh and Volsko (2008) whose study on the readability of 100 randomly-chosen web based articles from organisations for five common health conditions in the US, found mean RGLs of 11.80, 9.85, and 13.10 for SMOG, F-K, and Gunning FOG respectively. Likewise, McInnes and Haglund (2011) identified a mean RGL of 12.30 for Gunning FOG, SMOG, F-K and a mean FRE score of 46.08; also consistent with a college reading level, for 352 webpages related to searches on 22 different health conditions. Cheng and Dunn's (2015) readability analysis of Australian health-related websites found mean RGLs for F-K and SMOG of 10.54 and 12.12 respectively, and a mean FRE score of 47.54; also consistent with a college reading level. While these studies covered a broad range of health conditions that may not have included HI, their findings are similar to the current study, highlighting that online health-related information generally exceeds the recommended 6th grade reading levels.

The findings in the current study were also in agreement with two studies that investigated the readability of web-based materials related to HI. Atcherson et al. (2014) determined a mean, composite RGL score of 10.5 via the use of three readability formulas: FRE, F-K, Gunning FOG, and FORCAST, for the analysis of 225 audiology and speech-language pathology-related articles available on the ASHA website. This RGL was somewhat lower than the 11.2 mean RGL measured prior to a 2011 effort by ASHA to improve the readability of audiological material on their website. Similarly, Laplante-Lévesque et al. (2012), found mean RGLs of 11.10 and 12.36 for F-K and SMOG, and an FRE score of 48.26; consistent with a college reading level, for 66 websites retrieved using keyword searches related to HI.

The second research question aimed to determine whether the readability levels in the current study were significantly higher than the 6th grade levels widely-recommended by many researchers (Cheng & Dunn, 2015; Eloy et al., 2012; McInnes & Haglund, 2011; Misra et al., 2012; Narwani et al., 2015; C. R. Patel et al., 2015; Walsh & Volsko, 2008). Using a one-sample t-test in order to compare the RGLs from F-K and SMOG to a test value of six to represent 6^{th} grade, the mean RGLs were found to be significantly higher. The test was unable to be performed on the mean FRE score, as the score represents a reading difficulty score out of 100, and therefore could not be directly compared to RGLs, which are typically scored out of 19.

4.1.2 Webpage origin.

The third and fourth research questions aimed to investigate whether there were significant differences in readability for webpages with differing OOs and COs. To summarise, the OOs included: commercial, government, and non-profit entities, and the COs included: America, Australia, UK, and Other. Although this study included a large number of webpages in its analysis, when websites were coded for OO and CO, some of the sample sizes were too small to undergo statistical analysis. Furthermore, for the analysis that involved a main effect of OO, the CO Australia contained just one non-profit sample, which violated the assumption principles of the statistical analysis. In order to continue with the analysis, 34 samples that had non-profit OOs, had to be removed. The analysis found that webpages of a commercial origin had lower (better) readability than webpages of a governmental origin based on the RGLs determined by SMOG, and the FRE scores. However, for the F-K readability formula, there was no significant difference between the OOs included in the analysis.

These findings are in contrast to the recommendations from National Institute of Aging (2014). The National Institute of Aging (2014) suggested that websites sponsored by Federal Government agencies, large professional organisations, and well-known medical schools are “good” sources of information. While these websites may be seen to provide accurate information, this was an aspect that was not assessed in the current study. The issue of accuracy adds a further layer of complexity, in addition to the problems the general population of consumers may already face, in trying to comprehend information that is often too difficult to read. For example, if the RGL of the health-related information was at the recommended levels but the information was inaccurate, then this too, could hinder consumers’ ability to undertake a health-related action, such as correctly using HPDs to reduce noise exposure.

Interestingly, while the organisation origin of webpages was recorded in Laplante-Lévesque et al. (2012), and used to measure quality, the authors did not publish readability information specific to each organisation. In Laplante-Lévesque et al. (2012), 64% of the sample of webpages had a commercial origin, with 21% non-profit, and 15% governmental in origin. Similarly, in the current study, most of the webpages were of a commercial origin (52.94%), while 22% were non-profit and 24% were governmental. The different proportions of each organisation origin between the current study and Laplante-Lévesque et al. (2012) are likely associated with the sample size in the latter being less than half that of the current study (66 versus 153). However, the different proportions of commercial and governmental webpages between the two studies could also reflect the fact that the keywords used in the current study: “hearing loss claim”, “industrial hearing loss”, “hearing loss noise”, “NIHL”, and “NIHL claims” are more likely to be affiliated with government legislation and compensation than the keywords used in Laplante-Lévesque et al. (2012), namely, “hearing loss” and “hearing aids”.

Potter (2015) analysed an even larger sample than the current study. Among a total of 510 webpages, 48.82% were commercial, 24.5% were non-profit, and 26.67% were governmental. The figures for organisation origin in Potter (2015) closely reflect those in the current study, even though Potter (2015) used the same keywords as Laplante-Lévesque et al. (2012). This could mean that, when the sample size is large enough, if a search includes a keyword related to HI, around half of the response pool will be from commercial webpages, with non-profit and governmental webpages sharing the remaining two quarters. Unlike the current study, however, Potter (2015) found no significant difference in the readability of webpages from different origins. This was most likely attributed to the fact that searches for the Potter (2015) study were performed via the New Zealand ccTLD of Google, and thus were more likely to include results with a New Zealand origin.

While the majority of webpages in the current study were from UK and US origins (as depicted in Table 3), for Australia, Canada, and New Zealand ccTLDs, results were more commonly from OOs that matched their ccTLDs, i.e., the New Zealand ccTLD was more likely to return webpages with a New Zealand origin. For Canada, the results were more likely to be commercial COs and for Australia and New Zealand, government COs, were greater in number than commercial or non-profit. The fact that there were no significant differences in readability for a main effect of country may be associated with the current study's coding for country. The current study coded COs as: Australia, UK, USA, or Other, where each group reflected approximately one-quarter of the sample size. While it would have been interesting to examine the interactions of each of the COs identified in the search, small sample sizes prevented further investigations of the seven COs that made up the "Other" group.

4.2 Health On the Net certification

The current study included a sample size of 153 webpages. Among those, eight had a HON certification. A chi-squared test for independence was used to determine whether there were significant interactions between OO or CO and the presence of a HON certification. HON certification was spread fairly evenly across organisations, with 3 commercial, 3 governmental, and 2 non-profit webpages out of the eight identified as HON certified. It is not surprising, therefore, that there was no significant interaction between HON and OO. The low presence of HON certification reflects the findings in Laplante-Lévesque et al. (2012), whose sample of 66 webpages included only nine that were HON certified. In contrast to the current study however, Laplante-Lévesque et al. (2012) found a significant interaction between OO and the presence of HON certification where websites of a government origin were significantly more likely to be HON certified.

However, the current study did find a significant interaction between CO and HON certification. This finding was expected given HON was only present in websites from UK and USA origins. Country of origin was not recorded in Laplante-Lévesque et al. (2012), and this may be due to the authors using five ccTLD versions of Google. However, CO was recorded for the current study, with the inclusion of searches across 26 different ccTLDs. Country of origin consideration and the higher number of ccTLDs were included in an effort to assess English NIHI-related online information on a more global scale.

4.3 Clinical Implications

There are several findings from chapter one that should be considered. First, NIHI is one of the most common health issues associated with exposure to noise (Pawlaczyk-Luszczynska et al., 2013; Pelegrin et al., 2015). Second, low health literacy is a common issue associated with (among other things) lower use of preventative health interventions (Gazmararian et al., 1999; Scott et al., 2002). Finally, the Internet is an increasingly popular source for health-related information seeking (Fox, 2011; Hesse et al., 2005; Shuyler & Knight, 2003). This study was based upon the assumption that, given NIHI and Internet use are common; it is likely that consumers look to the Internet for information associated with NIHI. The current study's findings reflect other research findings associated with the readability of online, health-related information. Specifically, that information commonly exceeds the recommended 6^{th} grade levels (Cheng & Dunn, 2015; Eloy et al., 2012; McInnes & Haglund, 2011; Misra et al., 2012; Narwani et al., 2015; C. R. Patel et al., 2015; Walsh & Volsko, 2008). It can be assumed, therefore, that low levels of literacy, combined with poorly written material, have an effect in the uptake of aspects of HCPs and further, influence the rates of NIHI.

It is therefore paramount that health professionals who work with individuals affected by NIHI, including: employers, educators, audiologists, general practitioners, and otolaryngologists, follow the recommendations from Nutbeam (2008), who suggested that by improving the current understanding of the impacts of low health literacy on individuals and the population, and improving the quality of communication (as per Figure 1) by healthcare providers to their patients, the issues of low health literacy can be addressed.

Improving the quality of communication could be achieved by simply transcribing written material associated with NIHI into Word documents and using the F-K and FRE formulas that are freely available in Microsoft Word to determine RGL estimates. While this approach would not be recommended for large-scale analyses, as the results provide less information than a designated readability software would, it is an easy, free, and fast approach for professionals to check that the RGLs associated with consumer materials are suitable for the intended audience.

4.4 Limitations

This study has several limitations associated with its methodology and analysis. Firstly, although Google Trends was used to determine keywords for the webpage search, keywords used by consumers for information associated with NIHI may differ and may be used on other search engines. Further, the search in the current study was restricted to include English written information for the first 10 relevant websites, as well as any relevant associated webpages, accessed from a personal computer. This meant that the current study did take into account: information available in languages other than English, alternative multimedia including videos, pictures, figures and tables, or webpage information available on mobile phone platforms. Although great care was taken, the webpages that underwent analysis were possibly subject to human error. This could have involved: potentially missed information when data were copied to Word documents, the possibility of incorrect coding of the CO or OO, and unintended selection bias of webpages and relevant embedded links.

While the three readability formulas used in the current study are said to correlate well when used in conjunction with one another (Cheng & Dunn, 2015; Meade & Smith, 1991), the FRE formula presented a limitation associated with the fact that it scores out of 100 for reading difficulty, rather than a RGL out of 19 like F-K and SMOG. This meant that the FRE results had to be excluded from the one-sample t-test to that determined results were significantly different from 6th grade. However, given that the mean FRE score in this study was consistent with a college reading level, it is likely that it would have been significantly higher than 6th grade.

The findings in the current study are also limited by the fact that the Internet is an ever-changing source of information. The results in this study reflect information available at a particular time, namely September 2016, which may be different if the search were to be replicated later. Furthermore, the nature of the readability formulas used means that readability scores can change each time a piece of text is analysed, based on which part of the text the formula runs its analysis on. Therefore, the levels in each analysis only provide an estimated readability of the text.

The current study used the presence of a HON certificate to determine webpage quality. Due to time and resource constraints, other quality measures including the 16-item DISCERN quality criteria (Charnock, Shepperd, Needham, & Gann, 1999) used in Laplante-Lévesque et al. (2012) and Potter (2015) were not implemented in the current study. Due to the low numbers of HON certified websites available, the quality of websites was not properly assessed by this measure. Furthermore, aspects such as design, layout, and font, which have been found to contribute towards perceptions of trust among consumers (Robins, Holmes, & Stansbury, 2010), were not assessed in this study.

While the initial sample size was large, some of the samples that were coded for country and organisation were too small to undergo analysis. As stated earlier, 34 non-profit samples had to be removed from the ANOVA analysis and therefore their level of interaction with commercial and governmental webpages was not investigated. Likewise, for the seven COs that made up the “Other” group, individual readability scores and interactions could not be analysed. This could be remediated by analysing a larger sample than the first 10 websites. However, given the initial search included 1300 websites (26 ccTLDs x 5 keywords x 10 relevant websites), as well as 25 relevant embedded links, and was reduced to 153 webpages after duplicates were removed, it is unlikely that increasing the sample size would have returned new websites that were not already in the analysis.

4.5 Further research

Future research could focus on the readability and quality of non-web-based material associated with NIHI. This could include the analysis of videos, seminars, training booklets, and brochures associated with the educational portion of hearing conservation programs. Additionally, both verbal and written information given to consumers by health-related professionals, such as that in a hearing test appointment, should be examined. This analysis would be somewhat more complex than that in the current study. Verbal information analysis would have to include the recording and subsequent transcribing of spoken information before it was analysed. The analysis of information is just the first step in the process. Following the establishment of a more detailed evidence base for low readability rates for written information, studies could shift their focus to adapting materials in order to improve readability and quality for consumers.

4.6 Conclusions

The current study aimed to analyse the readability of online information related to NIHI available across 26 different ccTLD versions of Google. Using F-K, FRE, and SMOG readability formulas, the mean readability of webpages was found to significantly exceed the recommended 6^{th} grade levels. Findings were in line with several, previous readability studies pertaining to web-based information. Given that NIHI material can include information on causes, prevention, and treatment associated with NIHI, its inaccessibility could potentially influence the rates of NIHI.

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World Health Organization. (2015b). *Hearing loss due to recreational exposure to loud sounds*. Retrieved from http://www.who.int

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Appendix A

Webpage URL	ID	HON Cert	Establishment	Country	FRE	F-K	SMOG
http://american-hearing.org/disorders/noise-induced-hearing-loss/	1	No	Non-profit	USA	53	11.4	13.3
http://blogs.findlaw.com/injured/2015/03/whats-the-time-limit-for-a-workers-comp-claim.html	2	No	Commercial	USA	61	10	12.7
http://blogs.findlaw.com/injured/2015/04/can-i-get-workers-comp-for-hearing-loss.html	3	No	Commercial	USA	57	11.3	13.6
http://blogs.findlaw.com/injured/2015/04/is-my-injury-work-related.html	4	No	Commercial	USA	55	10.5	14.1
http://dangerousdecibels.org/education/information-center/noise-induced-hearing-loss/	5	No	Non-profit	USA	54	11	12.8
http://emedicine.medscape.com/article/857813-overview	6	Yes	Commercial	USA	30	15.3	16.2
http://hearinghealthfoundation.org/what-is-nihl	7	No	Non-profit	USA	53	10.5	13
http://journals.lww.com/thehearingjournal/fulltext/2013/04000/Work_Related_Hearing_Loss_Claims___Conclusive_Data.10.aspx	11	No	Commercial	USA	39	16.6	16.6
http://newyork.cbslocal.com/2015/12/18/firefighter-siren-lawsuit/	14	No	Commercial	USA	50	12.3	14.1
http://www.alllaw.com/articles/nolo/personal-injury/claims-hearing-loss.html	30	No	Commercial	USA	40	12.8	15
http://www.asha.org/public/hearing/Noise-and-Hearing-Loss-Prevention/	31	No	Non-profit	USA	57	9.3	11.9
http://www.betterhearing.org/hearingpedia/hearing-loss-prevention/noise-induced-hearing-loss	35	No	Non-profit	USA	51	11.2	13.4
http://www.caohc.org/pdfs/Determining%20When%20Hearing%20Loss%20is%20Work%20Related.pdf	38	No	Non-profit	USA	32	15.5	16.7
http://www.cdc.gov/niosh/programs/hlp/	39	No	Government	USA	23	15.5	17
http://www.healthline.com/health/acoustic-trauma	44	Yes	Commercial	USA	50	10.9	13
http://www.medicinenet.com/noise_induced_hearing_loss_and_its_prevention/article.htm	84	Yes	Commercial	USA	40	12.9	15.6
http://www.nolo.com/legal-encyclopedia/getting-veterans-disability-compensation-vision-hearing-loss.html	89	No	Commercial	USA	40	14	14.9
http://www.onr.navy.mil/Science-Technology/Departments/Code-34/All-Programs/warfighter-protection-applications-342/Noise-Induced-Hearing-Loss.aspx	90	No	Government	USA	0	19	19
http://www.tandfonline.com/doi/full/10.3109/03014460.2010.513774	102	No	Commercial	USA	30	18.6	18.5
http://www.vietnow.com/va-claims-hearing-loss/	109	No	Commercial	USA	56	11.6	13.5
https://en.wikipedia.org/wiki/Irish_Army_deafness_claims	122	No	Non-profit	USA	15	19	19

https://en.wikipedia.org/wiki/Noise-induced_hearing_loss	123	No	Non-profit	USA	16	19	19
https://en.wikipedia.org/wiki/Occupational_hearing_loss	124	No	Non-profit	USA	29	16.1	16.8
https://public.health.oregon.gov/HealthyEnvironments/WorkplaceHealth/Documents/Edition7Noise.pdf	125	No	Government	USA	33	15.3	16.5
https://www.cdc.gov/niosh/topics/noise/stats.html	136	No	Government	USA	42	14.5	14.7
https://www.millerandzois.com/hearing-loss-settlement.html	142	No	Commercial	USA	57	12.5	12.9
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4399645/	143	Yes	Government	USA	25	17.3	18
https://www.nidcd.nih.gov/health/noise-induced-hearing-loss	145	Yes	Government	USA	59	9.5	11.9
https://www.osha.gov/SLTC/noisehearingconservation/	146	No	Government	USA	48	11.7	13.7
https://www.truhearing.com/more-resources/noise-induced-hearing-loss-nihl/	150	No	Commercial	USA	49	11.2	13.2
http://hearinglossadvice.co.uk/faqs/can-i-get-compensation/	8	No	Commercial	UK	51	12.1	14.4
http://home.bt.com/lifestyle/money/money-tips/warning-after-hearing-loss-compensation-claims-rocket-11363987271723	9	No	Commercial	UK	31	19	17.1
http://insurance.dwf.law/news-updates/2016/03/nihl-fraudulent-behaviours-and-counter-strategies/	10	No	Commercial	UK	43	15.4	16
http://mla-ltd.co.uk/nihl-claims-shake-up/	13	No	Commercial	UK	35	16.1	17
http://www.agius.com/hew/resource/nihl.htm	29	No	Commercial	UK	49	11.8	14
http://www.asons.co.uk/industrial-disease/hearing-loss-claim/	32	No	Commercial	UK	54	11.1	13
http://www.bc-legal.co.uk/images/pdf/NIHLClaimsCollection.pdf	34	No	Commercial	UK	44	15.6	16.1
http://www.blmlaw.com/1975/21087/objects/events/nihl-claims-epidemic-in-england-and-wales---glasgow--25-oct-2016.html	36	No	Commercial	UK	39	15.1	16
http://www.blmlaw.com/2301/6496/objects/blm-e-bulletin-topic/the-employer--8217-s-date-of-knowledge-in-nihl-claims.html?mode=print	37	No	Commercial	UK	42	14.9	16.8
http://www.clydeco.com/insight/article/nihl-claim-levels-begin-to-fall	40	No	Commercial	UK	49	13.6	14.8
http://www.clydeco.com/insight/article/nihl-is-the-tide-turning	41	No	Commercial	UK	44	14.3	16
http://www.geldards.com/DPI-noise-induced-hearing-loss-claims.aspx	42	No	Commercial	UK	24	19	18.9
http://www.hse.gov.uk/food/noise.htm	50	No	Government	UK	36	16.1	16.5
http://www.hse.gov.uk/noise/demonstration.htm	51	No	Government	UK	51	11.3	13.2
http://www.hse.gov.uk/Statistics/causdis/deafness/index.htm	52	No	Government	UK	50	19	18.2

http://www.industrialdeafness.org.uk	54	No	Non-profit	UK	17	19	19
http://www.industrialdeafness.org.uk/acoustic-trauma	55	No	Non-profit	UK	35	18.1	17.4
http://www.industrialdeafness.org.uk/acoustic-trauma	56	No	Non-profit	UK	15	19	19
http://www.industrialdeafness.org.uk/causes-of-industrial-deafness	57	No	Non-profit	UK	26	17.5	17.7
http://www.industrialdeafness.org.uk/employers-legal-responsibility-concerning-industrial-deafness	58	No	Non-profit	UK	47	12.7	14.7
http://www.industrialdeafness.org.uk/industrial-deafness-claims	59	No	Non-profit	UK	42	14.3	16.5
http://www.industrialdeafness.org.uk/permanent-loss-of-hearing	60	No	Non-profit	UK	37	15.2	15.6
http://www.industrialdeafness.org.uk/preventing-industrial-deafness	61	No	Non-profit	UK	54	11.3	13.6
http://www.industrialdeafness.org.uk/symptoms-of-industrial-deafness	62	No	Non-profit	UK	38	17.7	16.6
http://www.industrialdeafness.org.uk/symptoms-of-industrial-deafness	63	No	Non-profit	UK	38	17.7	16.6
http://www.industrialdeafness.org.uk/temporary-loss-of-hearing	64	No	Non-profit	UK	38	16.2	16.2
http://www.industrialdeafness.org.uk/tinnitus	65	No	Non-profit	UK	35	18.1	17.4
http://www.industrialdeafness.org.uk/treating-industrial-deafness	66	No	Non-profit	UK	36	15.9	16.9
http://www.industrialdeafness.org.uk/what-is-my-industrial-deafness-claim-worth	67	No	Non-profit	UK	35	16.9	17.7
http://www.industrialdeafness.org.uk/workplaces-susceptible-to-industrial-deafness	68	No	Non-profit	UK	21	19	19
http://www.irwinmitchell.com/personal/personal-injury-compensation/industrial-disease-claims/noise-induced-hearing-loss-claims	74	No	Commercial	UK	47	12.4	14.6
http://www.kennedyslaw.com/article/toptipsfordefendingnoiseinducedhearinglossclaims/	77	No	Commercial	UK	39	12.8	14.5
http://www.kennedyslaw.com/events/NIHL2016/	78	No	Commercial	UK	43	12.5	14.5
http://www.lawgazette.co.uk/law/practice-points/noise-induced-hearing-loss-claims/5051007.fullarticle	80	No	Commercial	UK	45	13.7	15
http://www.lexology.com/library/detail.aspx?g=8bcbef85-ac81-40cf-b10c-0c7c3cfbfa23	81	No	Commercial	UK	45	14.8	15.7
http://www.medic8.com/healthguide/personal-injury/hearing-loss-claims.html	83	No	Commercial	UK	58	10.1	12.6
http://www.nhs.uk/Conditions/Hearing-impairment/Pages/Causes.aspx	87	No	Government	UK	45	12.9	14
http://www.noiseandhealth.org/article.asp?issn=1463-1741;year=2015;volume=17;issue=76;spage=158;epage=164;aulast=Halevi-Katz	88	No	Non-profit	UK	26	15.1	17
http://www.pannone.com/solicitors-for-you/personal-injury/industrial-disease/hearing-loss-claims/industrial-deafness	92	No	Commercial	UK	34	17	15.7

http://www.robertsjackson.co.uk/claim-guide/noise-induced-hearing-loss/	95	No	Commercial	UK	49	13.1	14
http://www.robertsjackson.co.uk/industrial-hearing-loss/	96	No	Commercial	UK	49	12.8	14.2
http://www.slatergordon.co.uk/personal-injury/injury-at-work/industrial-deafness-claims/	101	No	Commercial	UK	46	12.1	14.1
http://www.telegraph.co.uk/finance/newsbysector/banksandfinance/insurance/11676222/Insurers-raise-the-alarm-about-flood-of-noise-related-hearing-loss-claims.html	103	No	Commercial	UK	40	15.6	16
http://www.thisismoney.co.uk/money/bills/article-3126756/Is-industrial-deafness-new-whiplash-Claims-hearing-loss-suffered-work-surge.html	104	No	Commercial	UK	50	14	14.7
http://www.thompsons.law.co.uk/workplace-illnesses-and-diseases/industrial-deafness-personal-injury-compensation.htm	105	No	Commercial	UK	36	16.8	16.7
http://www.truthlegal.com/noise-induced-hearing-loss-claims/	106	No	Commercial	UK	44	13.3	15.1
http://www.yourhearing.co.uk/hearing-loss-claims/how-much-claim-value	121	No	Commercial	UK	54	12.5	13.4
https://www.abi.org.uk/~/media/Files/Documents/Consumer%20Guides/Tackling%20the%20Compensation%20Culture.pdf	126	No	Non-profit	UK	41	15.1	15.8
https://www.abi.org.uk/News/News-releases/2015/06/Industrial-Deafness-claims	127	No	Non-profit	UK	37	16.7	16.6
https://www.actiononhearingloss.org.uk/~/media/Files/Factsheets/Ears%20and%20ear%20health/pdf/Noise%20exposure%20May%202012.ashx	128	Yes	Non-profit	UK	60	9.5	11.8
https://www.actiononhearingloss.org.uk/supporting-you/rights-and-benefits/benefits-and-services/how-do-i-make-a-claim.aspx	129	Yes	Non-profit	UK	50	11.4	13.6
https://www.actiononhearingloss.org.uk/your-hearing/about-deafness-and-hearing-loss/types-and-cause-of-hearing-loss/noise.aspx	130	Yes	Non-profit	UK	49	12.6	13.8
https://www.brownejacobson.com/insurance/training-and-resources/legal-updates/2014/06/engineering-evidence-nihl-claims	131	No	Commercial	UK	38	15.9	16.5
https://www.farleys.com/5-things-you-need-to-know-about-noise-induced-hearing-loss-claims/	139	No	Commercial	UK	35	15	16.5
https://www.gov.uk/government/publications/noise-induced-hearing-loss	140	No	Government	UK	36	15.7	16
https://www.lexisnexis.com/uk/lexispsl/personalinjury/synopsis/471:134558/Types-of-claim/Deafness-claims	141	No	Commercial	UK	35	15.3	16.3

https://www.quittance.co.uk/personal-injury-compensation/noise-induced-hearing-loss-claims	147	No	Commercial	UK	48	11.6	13.9
https://www.yourlegalfriend.com/media/guides/your-guide-to-noise-induced-hearing-loss-claims/	157	No	Commercial	UK	50	13.1	15.1
https://yutreeunderwriting.wordpress.com/2015/02/23/noise-induced-hearing-loss-claims-as-a-broker-how-can-you-help-to-protect-your-clients-and-their-businesses/	158	No	Commercial	UK	41	13.8	15
http://randmutual.co.za/rma-content/uploads/2015/04/RMA-Connect-Class-IV-newsletter-Issue-3-2015.pdf	16	No	Commercial	South Africa	43	13.1	15.5
http://wiredspace.wits.ac.za/bitstream/handle/10539/7571/Chapter%203%20A%20Edwards%20PhD.pdf?sequence=3	18	No	Commercial	South Africa	27	18	18.5
http://www.labour.gov.za/DOL/downloads/legislation/regulations/compensation-for-occupational-injuries-and-diseases/Regulation%20-%20171%20-%20COID%20-%20Instruction%20on%20permanent%20disablement%20from%20hearing%20loss.pdf	79	No	Government	South Africa	30	16.7	18.2
http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S0038-223X2012001000006	100	No	Commercial	South Africa	34	17	17.3
http://www.acc.co.nz/making-a-claim/how-do-i-make-a-claim/ECI0010	19	No	Government	NZ	67	8	11.2
http://www.acc.co.nz/making-a-claim/what-support-can-i-get/ECI0018	20	No	Government	NZ	55	11	13.2
http://www.acc.co.nz/PRD_EXT_CSMP/groups/external_communications/documents/reference_tools/wpc091132.pdf	21	No	Government	NZ	30	16	17.3
http://www.acc.co.nz/PRD_EXT_CSMP/groups/external_ip/documents/reports_results/wim2_065096.pdf	22	No	Government	NZ	20	17.7	18.8
http://www.acc.co.nz/PRD_EXT_CSMP/groups/external_ip/documents/reports_results/wpc120108.pdf	23	No	Government	NZ	27	18.1	18.3
http://www.acc.co.nz/PRD_EXT_CSMP/groups/external_ip/documents/reports_results/wpc120117.pdf	24	No	Government	NZ	0	19	19
http://www.acc.co.nz/PRD_EXT_CSMP/groups/external_ip/documents/reports_results/wpc120203.pdf	25	No	Government	NZ	19	17.9	18.7
http://www.acc.co.nz/preventing-injuries/at-work/occupational-health/PI00081	26	No	Government	NZ	61	9.7	11.9
http://www.acc.co.nz/preventing-injuries/at-work/occupational-health/PI00081	27	No	Government	NZ	62	9.7	12
http://www.health.govt.nz/your-health/services-and-support/disability-services/types-disability-support/hearing-and-vision-services/hearing-services/other-services-people-who-are-deaf-or-having-hearing-	43	No	Government	NZ	51	12.6	13.6

loss							
http://www.listener.co.nz/lifestyle/health/noise-induced-hearing-loss-and-acc-claims/	82	No	Commercial	NZ	52	12.5	13.6
https://www.nfd.org.nz/our-work/national-advocacy-and-support/acc-funding/	144	No	Non-profit	NZ	54	11.9	12.9
http://www.acoustics.ie/2016/08/29/noise-induced-hearing-loss-nihl-history/	28	No	Commercial	Ireland	29	17.7	17.6
http://www.injury-compensation.ie/hearing-loss-injury-compensation/	69	No	Commercial	Ireland	41	14.7	16.7
http://www.injuryie.com/hearing-loss-compensation-claim/	70	No	Commercial	Ireland	41	15.7	16.5
http://www.irishhealth.com/article.html?con=645	72	No	Commercial	Ireland	63	8.7	11.2
http://www.irishstatutebook.ie/eli/1998/act/12/enacted/en/print.html	73	No	Government	Ireland	34	16.6	17.4
http://www.moloneysolicitors.ie/personal-injury/noise-induced-hearing-loss-claims	85	No	Commercial	Ireland	46	12.2	14.9
http://www.personalinjuryireland.ie/compensation-hearing-loss-work/	93	No	Commercial	Ireland	27	19	19
https://www.deafhear.ie/DHFiles/docs/Noise%20Exposure%20and%20Hearing%20Loss.pdf	137	No	Non-profit	Ireland	48	12.2	14.2
http://link.springer.com/article/10.1007/s12070-015-0855-2	12	No	Commercial	India	32	18.9	16.6
http://www.owa.gov.on.ca/en/filingclaim/Pages/Noise-Induced-Hearing-Loss.aspx	91	No	Government	Canada	55	11.8	14.6
http://www.protectear.com/blog/2012/08/09/hearing-loss-by-occupation/	94	No	Commercial	Canada	51	10.6	13.1
http://www.veterans.gc.ca/eng/services/after-injury/disability-benefits/benefits-determined/entitlement-eligibility-guidelines/hearing_loss	108	No	Government	Canada	26	16.6	17.7
http://www.wcb.ns.ca/About-Us/News-Room/News-Archive/2014/Occupational-hearing-loss-policy-change-January-1-2015.aspx	110	No	Government	Canada	35	14.5	16

http://www.worksafenb.ca/docs/Noise-Induced-Hearing-Loss.pdf	113	No	Government	Canada	45	11.7	13.4
http://www.wsiat.on.ca/english/mlo/hearing_loss.htm	114	No	Commercial	Canada	31	14.9	15.9
http://www.wsib.on.ca/WSIBPortal/faces/WSIBArticlePage?fGUID=939604048075000803&_afrLoop=311742063143858&_afrWindowMode=0&_afrWindowId=null#%40%3F_afrWindowId%3Dnull%26_afrLoop%3D311742063143858%26_afrWindowMode%3D0%26fGUID%3D939604048075000803%26_adf.ctrl-state%3Dolazl9l1s_4	115	No	Commercial	Canada	44	17.6	16
http://www.wsib.on.ca/WSIBPortal/faces/WSIBDetailPage?cGUID=WSIB014146&rDef=WSIB_RD_ARTICLE&_afrLoop=39202280728000&_afrWindowMode=0&_afrWindowId=18vi2wkobj_526	116	No	Commercial	Canada	32	16.9	16.7
http://www.wsib.on.ca/WSIBPortal/faces/WSIBDetailPage?cGUID=WSIB063881&rDef=WSIB_RD_ARTICLE&_afrLoop=38578519262000&_afrWindowMode=0&_afrWindowId=null#%40%3FcGUID%3DWSIB063881%26_afrWindowId%3Dnull%26_afrLoop%3D38578519262000%26rDef%3DWSIB_RD_ARTICLE%26_afrWindowMode%3D0%26_adf.ctrl-state%3D18vi2wkobj_29	117	No	Commercial	Canada	55	11	13.4
http://www.wsib.on.ca/WSIBPortal/faces/WSIBDetailPage?cGUID=WSIB063890&rDef=WSIB_RD_ARTICLE&_afrLoop=39109112308000&_afrWindowMode=0&_afrWindowId=18vi2wkobj_351#%40%3FcGUID%3DWSIB063890%26_afrWindowId%3D18vi2wkobj_351%26_afrLoop%3D39109112308000%26rDef%3DWSIB_RD_ARTICLE%26_afrWindowMode%3D0%26_adf.ctrl-state%3D18vi2wkobj_429	118	No	Commercial	Canada	34	15.9	16.1
http://www.wsib.on.ca/WSIBPortal/faces/WSIBDetailPage?cGUID=WSIB063890&rDef=WSIB_RD_ARTICLE&_afrLoop=39148804563000&_afrWindowMode=0&_afrWindowId=18vi2wkobj_451#%40%3FcGUID%3DWSIB063890%26_afrWindowId%3D18vi2wkobj_451%26_afrLoop%3D39148804563000%26rDef%3DWSIB_RD_ARTICLE%26_afrWindowMode%3D0%26_adf.ctrl-state%3D18vi2wkobj_479	119	No	Commercial	Canada	46	11.6	13.4
http://www.wsib.on.ca/WSIBPortal/faces/WSIBDetailPage?cGUID=WSIB063891&rDef=WSIB_RD_ARTICLE&_afrLoop=39170423541	120	No	Commercial	Canada	26	15.3	16.5

000&_afrWindowMode=0&_afrWindowId=18vi2wkobj_476#%40%3FcGUID%3DWSIB063891%26_afrWindowId%3D18vi2wkobj_476%26_afrLoop%3D39170423541000%26rDef%3DWSIB_RD_ARTICLE%26_afrWindowMode%3D0%26_adf.ctrl-state%3D18vi2wkobj_504							
https://www.emccanada.org/blogs/emcs360ofhealthsafety/pardonmedidyoujustsayhearinglossclaim	138	No	Commercial	Canada	52	11.2	13.8
https://www.wcb.mb.ca/noise-induced-hearing-loss	151	No	Government	Canada	9	19	19
https://www.wcb.yk.ca/QuestionResults/Claims/Filing/Q0076.aspx	152	No	Commercial	Canada	61	8.4	10.6
https://www.worksafebc.com/en/claims/report-workplace-injury-illness/types-of-claims/hearing-loss	155	No	Commercial	Canada	56	10.1	13
https://www.worksafebc.com/en/health-safety/injuries-diseases/hearing-loss	156	No	Commercial	Canada	61	8.8	11.1
http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1809-48642013000200015	99	No	Commercial	Brazil	26	17.2	17.9
http://www.hear-it.org/Noise-and-hearing-loss	45	No	Non-profit	Belgium	62	9.1	11.4
http://publicsector.sa.gov.au/wp-content/uploads/Noise-Induced-Hearing-Loss.pdf	15	No	Government	Australia	19	19	19
http://tgb.com.au/injured-people/i-suffered-hearing-loss-from-work-do-i-get-compensation/	17	No	Commercial	Australia	47	11	13.7
http://www.audioclinic.com.au/hearing-loss/types-and-treatment-for-hearing-loss/noise-induced-hearing-loss/	33	No	Commercial	Australia	51	11.3	13.3
http://www.hearingandaudiology.com.au/blog/2016/march/untreated-hearing-loss-takes-a-toll-on-relations.aspx	46	No	Commercial	Australia	43	13.7	15
http://www.hearingandaudiology.com.au/blog/2016/may/types-of-hearing-loss.aspx	47	No	Commercial	Australia	47	12.6	14.2
http://www.hearingandaudiology.com.au/blog/2016/september/industrial-hearing-loss-a-growing-issue-in-austr.aspx	48	No	Commercial	Australia	47	12.4	14
http://www.hearingandaudiology.com.au/services/hearing-tests.aspx	49	No	Commercial	Australia	42	13.3	14.8
http://www.industrialdeafness.com.au	53	No	Non-profit	Australia	27	16.4	17.5
http://www.iscrr.com.au/__data/assets/pdf_file/0007/297142/NIHL-assessment-for-workers-compensation-guidelines-2010.pdf	75	No	Commercial	Australia	34	16.1	17.1
http://www.iscrr.com.au/__data/assets/pdf_file/0010/299359/NIHL-Costs-and-determinants-NIHL.pdf	76	No	Government	Australia	37	15.4	16.2
http://www.nal.gov.au/hearing-loss-protection_tab_noise-exposure.shtml	86	No	Government	Australia	48	11.8	13.9
http://www.safeworkaustralia.gov.au/sites/swa/about/publications/Documents/539/Occupational_Noisein	97	No	Government	Australia	10	19	19

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http://www.safeworkaustralia.gov.au/sites/swa/about/publications/pages/rr200604workrelatednoiseinducedhearingloss	98	No	Government	Australia	28	17.8	18.3
http://www.turnerfreeman.com.au/qld/compensation-law/workers-compensation/	107	No	Commercial	Australia	31	15.4	16.8
http://www.workcover.wa.gov.au/workers/understanding-your-rights-obligations-entitlements/hearing-loss/	111	No	Government	Australia	42	13.7	14.9
http://www.worksafe.vic.gov.au/forms-and-publications/forms-and-publications/hearing-loss-claims-information-for-employers	112	No	Government	Australia	44	12.6	14.7
https://www.shine.com.au/service/workers-compensation/workcover-lawyers/industrial-deafness-claim/	148	No	Commercial	Australia	46	14.3	15.2
https://www.slatergordon.com.au/compensation-law/workers-compensation/hearing-loss-compensation	149	No	Commercial	Australia	51	12.9	13.7
https://www.workcover.nsw.gov.au/workers-compensation-claims/making-a-claim/types-of-claims/hearing-impairment-claims	153	No	Government	Australia	48	13.3	16
https://www.worksafe.qld.gov.au/rehab-and-claims/injuries-at-work/what-happens-after-a-claim-is-made/industrial-deafness	154	No	Government	Australia	45	12.2	14.5